INSERVICE TEACHERS TRAINING PROGRAMME IN SCIENCE AND MATHEMATICS

REPORT OF TRAINING PROGRAMME HELD ON BEHALF OF ORDNANCE FACTORY SCHOOLS

AT

REGIONAL COLLEGE OF EDUCATION

BHUBANESWAR

FROM 9TH JULY TO 18TH JULY, 1992.

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ORISSA

PREFACE

The NPE(1986) places special emphasis on improvement of Science and Mathematics Education in schools for better learning and teaching. In this direction MHRD has evolved several special schemes to meet its objectives. NCERT and RCE's as a nodal centres, have been organising several training programmes for inservice teachers to upgrade their content knowledge and also develop appropriate teaching skills and practices.

A request was received from the Directorate of Ordnance Factory, Calcutta to conduct a training programme for the teachers of the schools under its jurisdiction. A detail programme was worked out and a training programme for teachers in Science and Mathematics, at Secondary Level, was conducted at R.C.E.Bhubaneswar from 9th to 18th July,1992. Prior to this an Orientation Programme in Pedagogy was held at Ishapore.

In the Training Programme held at R.C.E.Bhubaneswar, an integrated approach to teaching of science was adopted. During the programme, the teachers were exposed to teaching strategies in Physics, Chemistry, Mathematics and Biology. Some of the misconcepts that were prevalent in the minds of teachers as well as students were cleared through discussion and logical conclusion with suitable examples. Also they were exposed to the contemporary development in scientific and mathematics fields. In the case of mathematics, some of the new topics which have been introduced into the curriculum were discussed in detail and the doubts expressed by teachers were cleared.

In this programme, a total of 13 teachers participated. Among them, there were 8 teachers teaching Physics and Mathematics, 5 teachers teaching biology and all of them together were teaching Chemistry. The team was divided into two groups i.e. Physics & Mathematics and Biology. For the first 5 days these groups was instructed separately in Physics and Mathematics & Biology and for the next 5 days, the combined group was instructed in Chemistry. The participation of all the teachers during the training programme was very satisfactory.

Finally, I thank all my colleagues in the department for extending their cooperation in conducting the programme. My special thanks are due to my colleague Shri M.A.Chandrasekhar, Reader in Physics who as Coordinator of the programme rendered his valuable help and suggestions not only during the programme but also while preparing this report. Also I thank the participants for their cooperation.

I will be failing in my duties if I do not extend my sincere gratitude to Prof.K.C.Panda, Principal of Regional College of Education, Bhubaneswar for his valuable guidance and suggestions from time to time for conducting this programme.

(Prof.N.Khattar)
Programme Director

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UNIVERSE AND ITS UNITS

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Every day a child sees the bright sun in the morning and in the night the moon , planets and millions of stars. The nature has provided such a beautiful observatory to explore but still very little thought is given to this aspect to motivate the students to learn more about the universe surrounding us.

A naked human eye can see things which is at a far off distance and also stars which are several light years away from us through their light. If you sit on a sea shore, you can view upto a distance of 5 miles where the horizon and sea meets. This is associated with the geometry of the earth. This human faculty is unique.

Astronomy being one of the oldest sciences, how to motivate students to learn more about the universe. Suppose a question like 'where do you live' is posed to a student, the expected answer is that he gives his address. But of course he has not really told you where he lives - in space.Let us locate ourselves in space as best as we can. Just what is our address in the universe.This is a very confusing question to answer because which ever direction we look, we see space. Just like when you are on high sea, you see blue water in every direction. Similarly which ever direction we look, we see galaxies and our galaxy seems to be at the center of the whole show. We know that we live on one of the nine planets that orbit the sun. We are told that the sun itself is speeding through space on an orbit of its own that takes it around the center of our galaxy - the Milky way. And our own galaxy also is a collection of billions of stars, companion to the sun. Further we know that our galaxy is but one of billions of galaxies.

Our apparent feeling of being at the center of the universe is an illusion just like you are in the midst of a huge crowd of people. You see nothing but people no matter whichever direction you look and feel that you are in the exact center of the of the crowd.

GALAXIES

What do galaxies look like? How they are distributed in space? How do they differ among themselves. So one may have an unending questions like this.

Our own galaxy, the Milky way, is in a highly flattened shape, which is the characterstic of a large class of

galaxies. We have no chance of seeing stars in the distant galaxies. The galaxies are not distributed uniformly in space, but seem to occur in spacious clusters. A single cluster may contain thousands of galaxies
However we may reasonably assume that galaxies are uniformly distributed. Each galaxy is a gigantic collection of stars, often containing as much or more non-luminous material, in the form of interstellar gas, dust and sub-luminous stars, than normal stars.

Most of the galaxies can be easily seperated into one of the four groups as suggested by Edwin Hubble (FIGURE-1)

(i) Spiral: that show loosely or tightly bound spiral arms.

(ii) elliptical in which the spiral arm are absent but which retains a lens shaped form in varying degrees of flattening or ellipitcity.

(iii) barrel spiral that exhibit a prominent bar through their central region and which sprout sprial arms from their end.

(iv) Irregular which seems to be just huge collection of stars, dust and gas without clear pattern.

INSIDE A GALAXY

What about our own galaxy? We can view this galaxy from inside. It is difficult to get an overall view of the house you live in if you are forever confined to the inside and can never go outside to take a look at it from across the road. It would be especially difficult if you could not wander around exploring first one room and then another. And such is our situation. However we do make a round trip of our galxy in the course of 260 million years as we tag along with the sun on its journey. Futher, the sun's orbit, lies fairly close to the central plane of our galxy and never brings us closer than some 25,000 light yeatrs to the galactic center. The other stars travel about the center of the galaxy too but at different speeds. The whole galaxy rotates like a giant pinwheel.

Our sun is too far away from the center of our galaxly that it is difficcult to get a detailed view of what the center looks like and also due to dusty space intervening. As a result only a fraction of 1% of the light from the central region of our galaxy gets through to us. Our galaxy appears to have more matter in the form of dust and gas than the matter in other galaxies in

the form of stars. These matter lies almost in the central plane of the galaxy. So the hallmark of sprial galaxy is the dust and gas. The elliptical galaxies are free from dust and gas; if we were on a elliptical galaxy we would have a far more clear view of the center of the galaxy. It was Galileo, with his telescope, who first resolved the milky haze into countless distant stars. The stars of the milky way, also travel around the center of the galaxy in orbits that lie close to the central plane. So when we look at the milky way in the sky, we are looking at the giant stellar pinwheel from the inside. (fig-2)

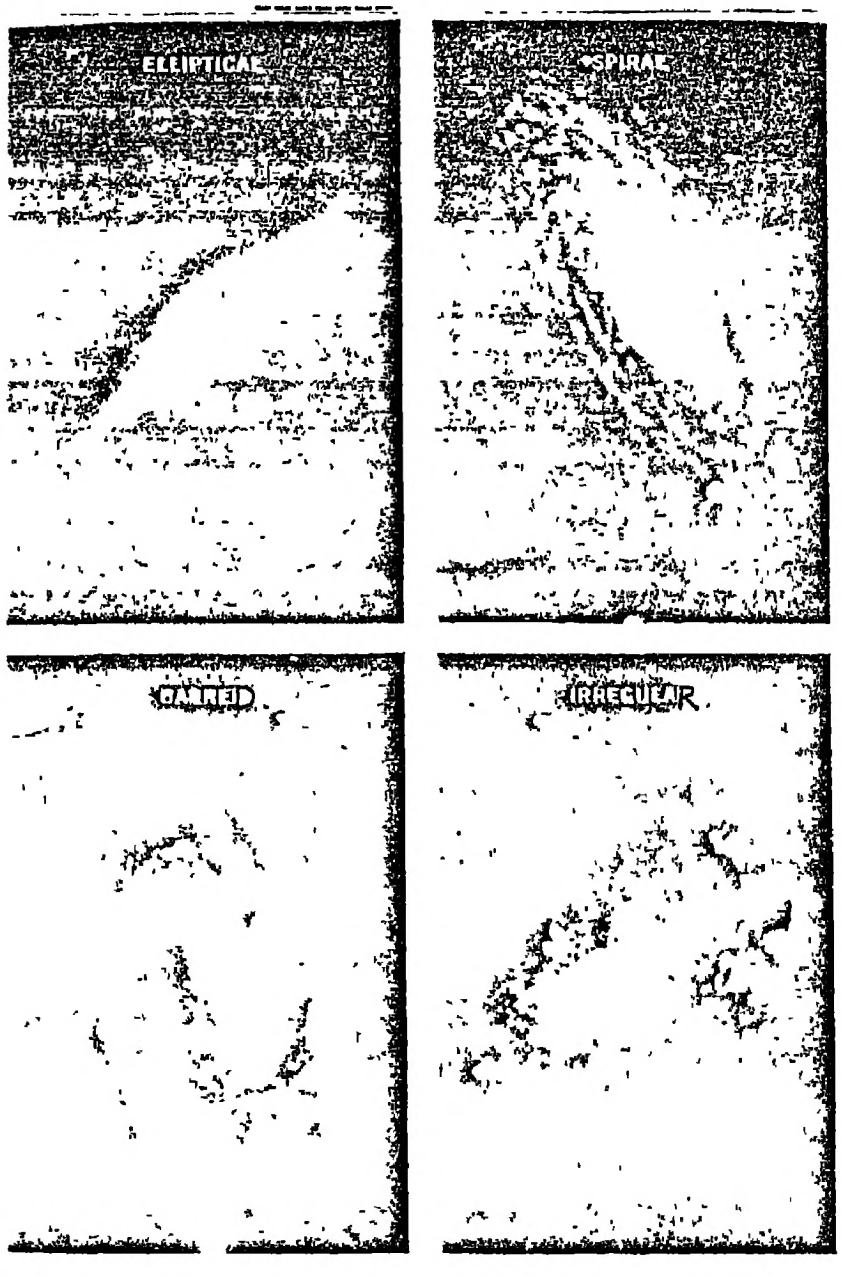

Fig - 1.

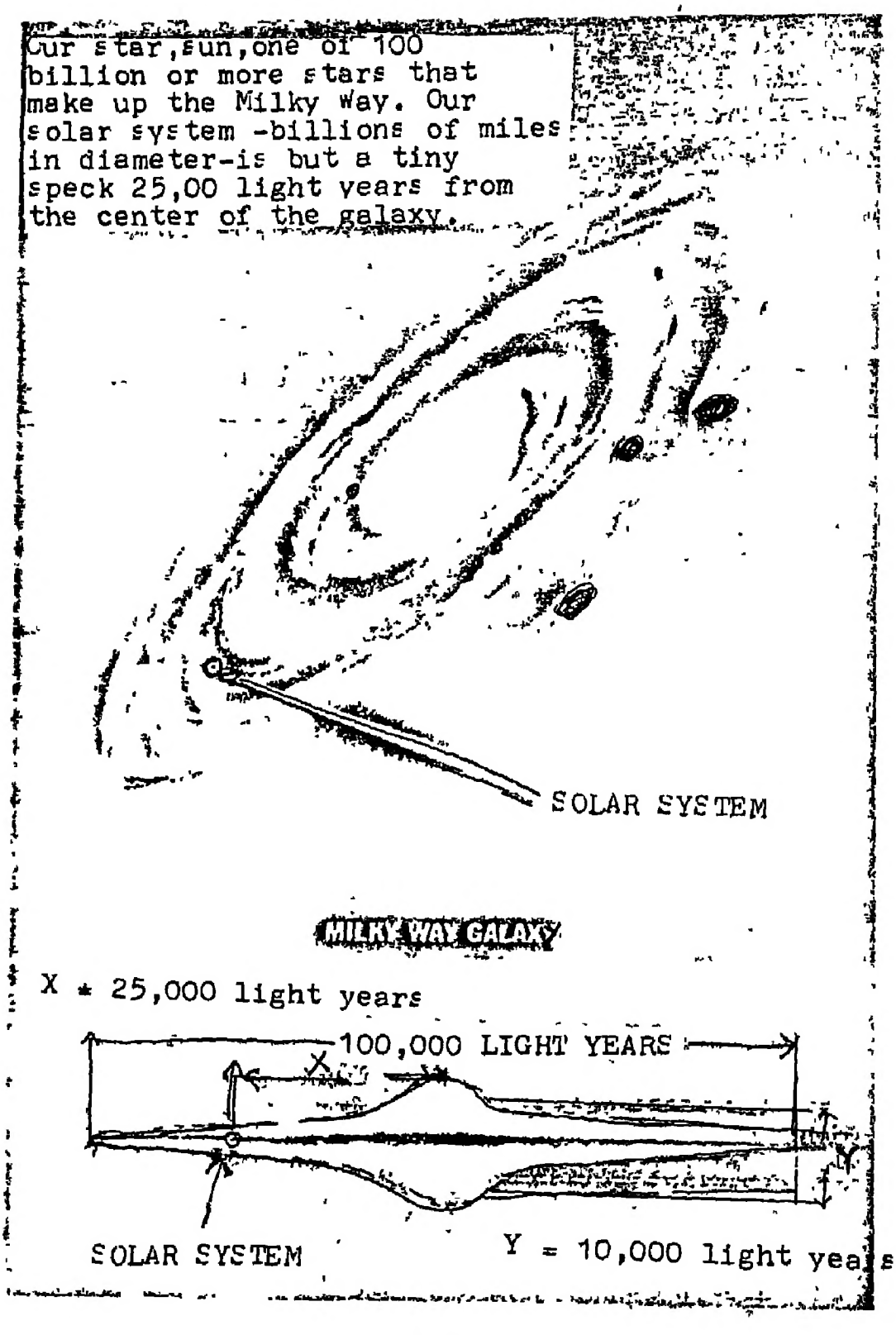
Our star, sun, one of 100 billion or more stars that make up the Milky Way. Our solar system -billions of miles in diameter-is but a tiny speck 25,00 light years from the center of the galaxy.
SOLAR SYSTEM
MILKY WAY GALAXY
X = 25,000 light years
100,000 LIGHT YEARS
X
SOLAR SYSTEM
Y = 10,000 light years

Fig-2.

MOTION AND FORCE

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Motion (remember 'REST' is a state of uniform motion- with zero velocity) and force are the most basic concepts that the child encounters in any book on physics. In fact the child is exposed to various phenomena, associated with these two concepts, very early in his /her life. So when one proceeds to teach these two concepts one is faced with two tasks. One - to identify what the child already knows i.e. what forms of cognitive structures already exist in his/her mind. Second - how to modify the existing ideas in his / her mind and teach the concepts of motion and force.

Concept of Rest:

It is taught to the students under Newton's first law of motion that a body at rest continues to be in that state of rest unless an unbalanced force acts on it. This is called the phenomena of inertia of rest. The most important term in this statement is 'unbalanced' . Students as well as teachers very often forget this. Ask the following questions.

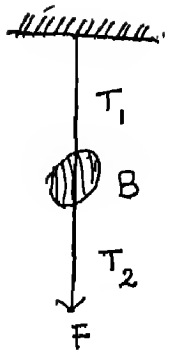
Question 1: A book is resting on a table. Are any forces acting on it? If you answer is YES, name the forces.

Question 2: A body is hanging from the the roof by means of a thread. Are there any forces acting on it? If your answer is YES, name the forces.

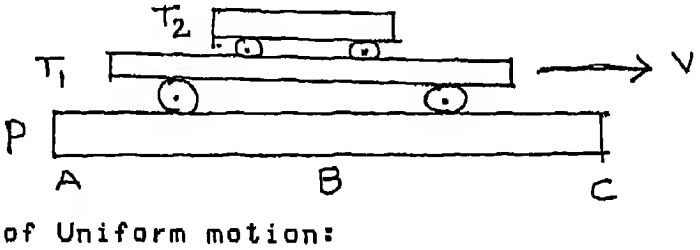
Once it is felt that the students have understood the concept of intertia of rest, use the following questions to test the degree of their compre-

hension.

Question 3: A body is hanging from the roof by means of the thread T1. A thread T2 of identical quality is hanging from the bottom of the body B. If T2 is pulled downwards with a force F, and the magnitude of F is increased, which thread, T1 or T2 will snap? Explain. If in a fresh set up, T2 is given a sudden jerk downwards, which thread will snap? Explain.



Question 4: On a frictionless platform P a frictionless trolley T1 is resting and on it a small frictionless trolley T2 is resting. Trolley T1 is pulled to the right with a constant velocity V. What will happen to trolley T2?. Will it move towards A, towards C or continue to remain at B with respect to P? Explain your answer.

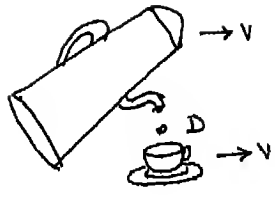


Concept of Uniform motion:

The second point of Newton's first law of motion states that a body in uniform motion continues to be in that state unless an unbalanced force acts on it. This phenomena is called inertia of motion. Again note that the most important word in this case is the term "unbalanced ". Ask the students to give common day examples of bodies in uniform motion, bodies which continue to be in that state of motion. They will fail to give a correct example. In fact many teachers will fail to give a correct example. Ask the students the

following questions.

Question 5: Take the case of a hawker, standing in a train which is moving with uniform velocity V, and trying to pour tea from the jug into a cup. The drop, D , of tea which has just come out from the jug is hanging in air and is not part of the jug. In the time the drop D takes to fall to the cup, the cup will move to the right with a velocity V as the man is holding the cup. So the drop of tea will not fall into the cup. Then how does the hawker pour tea into the cup?



While explaining Newton's first law of motion one also explains the terms distance, displacement, speed and velocity, give enough life centred examples to explain these concepts. Although these concepts appear to be simple, students do have various ideas about them. Check the degree of meaningful learning by asking questions of the following types.

Question 6: Can a body have unoform speed and nonuniform velocity? Explain your answer with examples.

Question 7: Can a body have uniform velocity and nonuniform speed? Explain

Question 8: Under what conditions the average speed of a body will be equal to the average velocity of a body?

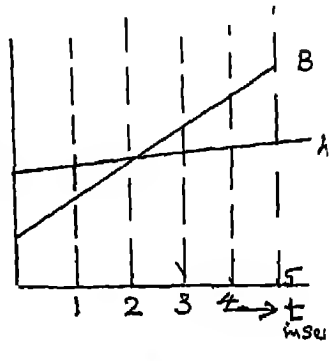
Question 9: Under what conditions the instantaneous velocity of a body will be equal to its average velocity?

One can also test their comprehension by asking ques-

tions involving the dispalcement - time and velocity - time graph of a moving body. Two examples are given below.

Question 10: A body remains at rest for 2 sec. Then it moves with a uniform velocity for 4 secs. It then stays at rest for 2 secs. Finally it comes back with a uniform velocity to the starting point in 2 secs. Draw the displacement - time and velocity - time graph of the body.

Question 11: The figure shows the displacement - time graph of two bodies A and B. At 1 sec. which body was moving faster? Do the two bodies have the same velocity at any time? If so what is the time ? At 4 sec. which body was moving faster? Explain your answer.



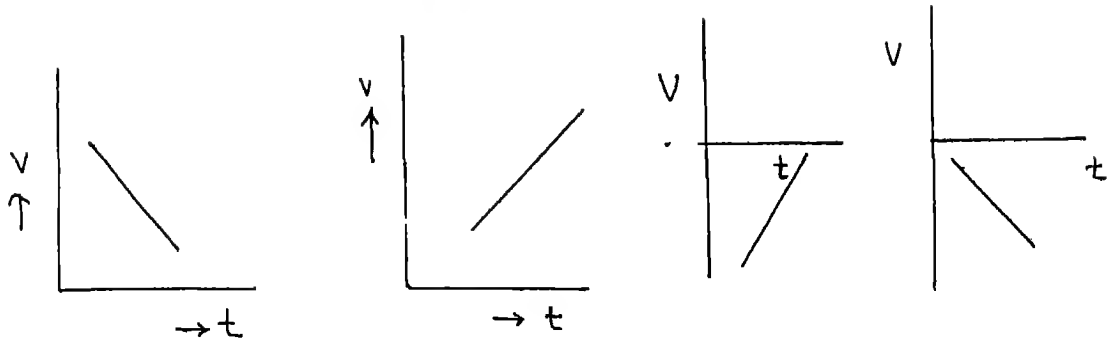
Before one starts discussing about force one should discuss the concept of acceleration in great details. Students do have the concept that a body having acceleration means the magnitude of its velocity is increasing. Teachers very often fail to emphasize that acceleration means change of velocity and change of velocity means either

(a) Change of only magnitude of the velocity or
(b) change of only direction of the velocity or
(c) change of both magnitude & direction of the velocity.

Ask the students to give examples of each case. Supplement them by giving new examples pooled from life centered experience. Ask the following questions.

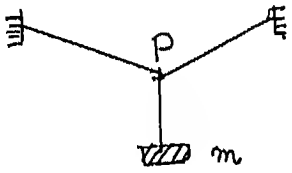
Question 12: Out of the four velocity - time graph in which case the body is accelerating?

It is worthwhile to analyse these four graphs.



While discussing about force, explain through demostration how force can poduce both acceleration and deceleration. Discuss how several forces acting at a point may produce no effect on ther state of a body. Ask them the following problems.

Question 13: A body of mass m is hanging from a rope fixed between two walls as shown in the figure. The force acting at the point P is the weight, mg , of the body. Are any other force acting there? If so find out their magnitudes and dirction.



Try to comprehend that force is equal to rate of change of momentum and not necessarily the product of mass and accelertion. There may be cases when the mass of the body might be changing as the body continues in its motion. Ask the follwoing question -

Question 14: When a rocket is accelerating upwards can we use the quation F = ma to study its motion? If, not why not?

Discuss about impulsive force and impulse with suitable examples like hammer hitting a nail or a cricket bat hitting a cricket ball. Then highlight the definition that force is equal to the rate of change of momentum.

BRIEF NOTE ON TEACHING OF LIGHT

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While teaching the unit of light at secondary level special care should be taken to see that the following concepts should be developed in the students and this fact should be tested as many times as possible.

(i) Logical necessity of the second law of reflection and refraction. It should be made clear that just the first law namely angle of incidence is equal to the angle of reflection, or sin i /sin r in refraction does not define the reflected /refracted ray uniquely in a given situation, although in the usual diagram on paper or board it appears to do so.

(ii) How virtual is a virtual image? The answer to this question is that a virtual image is as good as an object or even a real image as far as the points where light energy is reaching is concerned. The only virtual or imaginary part is that it does not exist where you think it is existing. This is the reason a virtual image can act as an object for the photographing lens and can even be photographed. One interesting way to ensure an interesting discussion on this is to draw a ray diagram showing the virtual image formation of a point object in a plane mirror ; and then ask the pupils to draw a 'ray diagram'showing the formation of real image (i.e. reflected rays meeting at a point and not appearing to meet,

(iii) An image of a point object is just not formed only by two rays but by many rays. Two rays are used just to easily locate the image point corresponding to an object point. To drive home this point, an image can be formed by a reading lens, of a distance object on the wall, and the pupils can be asked as to what would happen if different parts of the lens are blocked one by one.

(iv) Pupils also think that the laws of reflection apply only in the case of plane surfaces and some different laws are required for spherical surfaces. Special care should be taken to make them understand that the special rules involving focus, centre of curvature etc are derived from the fundamental laws only by applying them as such to small planes of the curved surface on which the incident ray falls. Similar difficulties should be taken care of while dealing with refraction at curved surfaces.

(v) Composition of white light by mixing primary

colours and the concept of secondary colours can be given by using filters, but also by viewing some coloured objects against a white background for 45 seconds and then withdrawing the object. The sensation of seeing the same object in secondary colour would be observed on the white background within 5 seconds. This activity can generate good discussion with pupils.

NOTES ON TEACHING OF ELECTRICITY & ITS EFFECTS

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The unit on Electricity and its effects finds its proper place in the secondary curriculum because it is fundamental to any theory of matter and also because our modern day civilization is totally dependent upon its technological applications. The teaching of the theoretical aspects of these units is important from the point of view of preparing the pupil for a more thorough study of the same to be undertaken at senior secondary level in the course on physics , whereas the applicational aspects are more important for enabling him to make optimum and appopriate use of electrical gadgets by understanding them and to caution him about the hazards that these gadgets may inflict on him. From this standpoint we can categories namely (i) theoritical and (ii) technological. The theoretical concepts can further be subdivided into basic concepts ano relational concepts. One such division is given below whcih can be modified according to local needs.

Theroretical concept - Basic	Relational	Technological
-Potential	coloumb's law	motor
current	ohm's law	dynamo
resistance	Lenz's law	galvonometer
power	Biots savart law	battery
energy	Joule's law	battery
short circuit	Amper's rule	Eliminator
Inuction	Flemings rule	fuse
electro-magnetic	equvilant	
induction	resistance (for series & parallel)	

This catergorisation will help the teacher to plan the teaching of unit and the individual lessons more effectively

Another inmportant aspect which should be kept in mind while teaching this unit is that when we define a concept we should also tall how it is measured bringing in the technological concept.. Such a definition is called operational definition. Some of you have asked me the difference between e.m.f and potetial difference of a cell. I am giving the definitions of these concepts theoretically and operationally as an illustration.

(i)Operational definiltions;

E.M.F of a cell is the potential difference between its electrodes when the cell is on open ciruit or no current is drawn from it. When the circuit is closed the potential

difference is less than e m f and is termed as just potential difference. By how much less depends upon the current drawn.

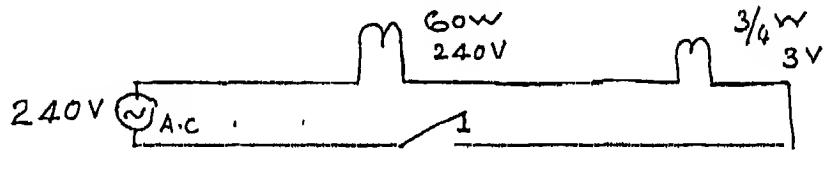
larger the current drawn greater is the difference . This I have demonstrated to you during my lecture

Theoretical difference:

The emf of a cell is the work done to take unit positive charge from one electrode of the cell to the same electrode round the ciruit, whereas the potential difference is the work done to take the unit positive charge from one electrode to other along external circuit. In the above definition the pharse numerically equal to ' is deliberately used to emphasize the different dimensions of potential and work. Such an approach can be generalized for teaching other concepts.

Educational researchs show that like mechanics, in this unit also pupils and sometimes ourselves also have certain misconceptions. These have to be prevented and if at all they occur in your pupils remedial measures have to be taken. After teaching the topic on current electricity (a.c & d.c) upto power, just try the follwing problem on your pupil. Asl them what will happen and why.

PROBLEM: What happens to the torch bulb in the following circuit when it is closed



figure

In this groue you have yuourself given different answers . Please try to justify your answer on the basis of Ohm's law and you can easily arrive at only one correct answer. Then think why your immediate reaction was erroneous. This activity.would help you to understand what goes wrong when your students commits a mistake.

Lastly I would like to emphasise that in order to enjoy the real excitement of teaching/learning physics in general and this unit in particular, we must train ourselves to think logically and experiment consciously with an open mind and keen sense of observation. As an illustration I request you to perform the following experiment actually (or in thought and perdict the result).

Experiment: Take a 1.5 volt cell and go on con necting 1.5 volt torch bulbs in parallel one after another. Observe the brightness of the bulbs at each step. If you can do this experiment, observe keenly and interpret your results. If you are thinking about this experiment , predict the result and justify it on the basis of concept of internal resistance of a cell.

WORK AND ENERGY

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We concentrated on points of doubt /misunderstanding in this and related topics which came up through discussions.

1. Participants showed the tendency to define work as the product of force and displacement, whereas it should actually be defined as the product of force and the displacement in the direction of force or equivalently, as the product of force in the dircetion of displacement and the displacement. The definition and the equivalance were explained using diagrams and the vectorial nature of force and displacement.

2. Work _energy theorm was derived and interpreted.

3. The distinction between 'work done by a body' and work done on a body' was stressed with examples.

4. Distinction was made between the physical meaning of work as already defined and the physiological meaning of work, taking,as an example, the case of a man standing stationary and holding a weight on his outstretched palm. Clearly , although the man is doing no physical work, he is definitely doing some amount of physiological work in the form of sweating, exhaustion etc.

5. The participants stated that in every circular motion there is a centripetal force and there is a centrifugal force acting on the body and the two forces

cancel each other. The point was discussed at some length with the help of illustration and it was shown ,.

that whereas centripetal force is essential for circular motion and is seen by a stationary observer as an actual force acting on the body towards the centre of the circular path, centrifugal force is a 'pseudo force' which can only be seen by an observer moving with the circulating body. The point that a body in circular motion is always acted upon by a net non-zero force and hence is not in equillibrium was also stressed.

SOLAR ENERGY

1. The supposed source of solar energy, namely the phenomenon of fusion ws explained with reference to the interior structure of the sun.

2. The two porposed chain reaction leading to the production of energy inside stars in general namely the C-N cycle and the direct p-p chain were written down explicitly in the form of chemical reactions. The various particles/radiations appearing /disappering in these reactions were explained.

3. Rate of energy generation inside the sun and the modes of its transmission to the exterior of the sun and beyond were discussed.

4. The importance of solar energy for the living world was emphasised.

WAVES AND OSCILLATIONS

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The secondary school is the appropriate place to con struct proper perspectives relating to human values in scientific enterprise. Possibily more progress has been made in re-shaping and modernising the school curriculum in science than in any other field. The basic aim of the orientation course is to make the secondary school science teachers aware of basic concepts of the curriculum and to eliminate the misconcepts they have regarding certain basic concepts in physics. Emphasis was being given here to demonstrate some simple experiments in the class room situation. Two topics from the secondary school curriculum were chosen.

1. Waves
2. Simple harmonic oscillations.

The following concepts were discussed:

1. Wave can be described by mathematical equations and each travelling or progressive wave is associated with certain velocity and acceleration. The kinitic energy of the wave in proportional to the square of the amplitude and its implications. Progrssive waves may be transverse , may be longitudinal. Longitudinal and transverse wave can be realised in practice even in a class room.

2. Stationary waves are also known as standing waves and formed when two exactly similar wave trains having same wave length, velocity and amplitude travel along the same straight line in a medium in opposite direction obeying the principle of superposition. Distinction between progressive and stationary wave was highlighted.

3. Sound wave is a longitudinal wave and can be reflected, refracted, interferred and diffracted under appropriate conditions. But polarization of sound wave is not possible because it is only possible in the case of transverse wave.

4. Echo is due to reflection of sound wave from an extended reflector. To hear echo certain conditions are to be satisfied like 56 feet should be the minimum distance of the reflector from the source.

5. Reverbaration is due to multiple reflection of sound wave and due to this phenomeon the sound persists even after the source is cut off.. A good audtorium means, it should have less time of reverbration and has to redue reverbaration to its mimimum value.

6. Simple harmonic motion (SHM) and simple experi ments relating to SHM like spiral spring and simple pendulum were

discussed and demonstrated.

7. Simple pendulum can be realised in practice by suspending a havey bob by a string from a rigid support because the ideal definition of a simple pendulum cannnot be realised in practice. Action of air resistance during the motion as a dissipati. force was also discussed.

8. The time period of oscillations of a simple pendulum does not depend on the mass or amplitude of the pendulum but depends on the length of the string of the pendulum. Ways can be demonstrated easily using the available materials in a secondary school.

9. Limitations of a simple pendulum and the defects of a simple pendulum which lead to the discovery of compound pendulum were discussed.

10 Compound pendulum and it's characterstics were discussed. Some ideas regarding the different types of compound pendulum were discussed.

MASSES OF ATOMS AND MOLECULES AND THE CONCEPT OF A MOLE

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Molecules of different substances are known to be made of atoms and atoms in their turn are made up of portons, neutrons and electrons. Therefore if we can determine their numbers and their respective masses we can deter mine the mass of an atom or a molecule.

What is the mass of a proton? What are the masses of a neutron and that of an electron. Experiments prove that the mass of a proton and neutron are very nearly the same and that of an electron is 1/1836 times that of a proton or a neutron. Therefore neglecting the mass of an elctron, the mass of an atom would be found to be associated with the nucleus and can be taken as the mass of the atom.

The masses of protons and neutrons have been very carefully determined to be equal to 1.67265×10^{-24} grams and 1.67495×10^{-24} grams and that of the electron has been found to be 9.0953×10^{-28} gram (incredibly small number) to be of any use to a chemist who is concerned with weight reltionship between reactants and products. However if we express the masses of atoms in terms of a unit as small as approximately 10^{-24} g defining it as one atomic mass unit abbriviated as a.m.u

We get convenient numbers for relative masses of not only atoms but also for neutrons and protons. To be exact, the unit chosen is 1/12 th of a carbon atom

consisting of six protons and six neutrons which in grams is equal to 1.66×10 g ($(1/12) \times 19.93 \times 10$), 19.93 being the mass of the above carbon atom measured carefully). Taking 1 a.m.u = 1.66×10 g, the masses of neutron and proton are 1.0086 and 1.00728 respectively which are taken as equal to one.

MASSES, MASS NUMBERS AND COMPOSITION OF SOME ATOMS

Atom	At No	Composition			Mass		Mass No
		Proton	Neutron	Electron	$X10^{-24}$ g	amu	
Hydrogen	1	1	0	1	1.6	1.0078	1
Helium	2	2	2	2	6.6	4.0319	4
Beryllium	4	4	5	4	14.98	9.0120	9
Flourine	9	9	10	9	31.55	18.998	19
Sodium	11	11	12	11	38.17	22.9900	23

*Mass numbers are obtained by rounding off the masses in a.m.u to the nearest whole number.

Chemical atomic weights: Experiments have rvealed the existance of atoms of the same element with different masses. Such atoms are called isotopes. Since most naturally occuring elements contain two or more isotopes, experiments have been conducted to determine the amount of each isotope present in the isotopic mixture found in nature. Results of these experiments show that in most cases one isotope is present in larger amount than the other. An weighted average consisting the masses of the isotopes and their relative abudance gives the chemical atomic weight or simply the atomic weight as illustrated below.

Mass no. Isotope	Mass of the Isotope(amu)	Relative abudance %	Contribution to mass of 100 atoms
20	19.992	90.92	90.92x19.992=1818
21	20.994	0.257	0.257x20.994= 5.4
22	21.991	8.82	8.82x21.991=194.0

Mass of 100 atoms =2017

Weighted average mass of one atome = 20.17

RELATIVE ABUDANCE OF ISOTOPES OF FEW ELEMENTS

Element	Isotope	Mass (amu)	Relative abu-dance in %	Atomic wt
H	$^{1}_{1}H$	1.007796	99.985	1.0079
	$^{2}_{1}H$	2.014068	0.015	
O	$^{16}_{8}O$	15.99468	99.759	15.9994
	$^{17}_{8}O$	16.99884	0.037	
	$^{18}_{8}O$	17.9972	0.204	
Cl	$^{35}_{17}Cl$	36.96944.	75.4	35.453
	$^{37}_{17}Cl$	36.96600	24.6	
Cu	$^{63}_{29}Cu$	63.0	69.0	63.546
	$^{65}_{29}Cu$	65.0	31.0	

CONCEPT OF A MOLE: Our most frequent encounter with atom is in handling very large numbers of them in elements.Compounds and mixtures we use everyday,whose mass we can determine but not the number. For example we can weigh a small strip of a magnesium ribbon quite accurately but we have no way to count the number of atoms in the strip. But it is important that we have some indication of the mubers of atoms present in any sample we use.

The laws of chemical combination were explained by assuming that atoms of elemnets combine in fixed ratios to form compounds. But when we wish to carry out a reaction we cannot count out or weight out individual atoms or molecules because of their unimaginable small size and mass. If it is known that two different kinds of atoms react in 1 to 1 ratio, then it is necessary to measure out masses of each type of atoms which contain an equal number of atoms. This situation demands the need for a chemical unit based on masses in which the basic unit will contain a specific number of atoms, molecules or ions of any subtance. This was decided by the chemists to be a mole and the standard for mole was chosen to be 12.011 grams of carbon of carbon -12. Since 12.011 ;4.0026 and 1.0079 are the relative weights of carbon,helium and hydrogen respecpetively 4.0026 & 1.0079 grams of helium and hydrogen will have same number of atoms as 12 grams of C-12 will have and will represent the mass of a mole of helium and hydrogen each respectivly. Relative masses of different atoms and molecules, therefore , when expressed in grams would represent a mole of them (earlier different names as gram atom, gram atomic weight, gram mole, gram molecular weight were used for atoms and molecules were used to convey a mole of any subtance)

Several methods have been used to determine the number of atoms or molecules present in a mole of any subtance . One such method is

A definite weight of copper, silver etc are deposited at the cathodes when a given quantity of current is passed through their salt solutions. Such experiments showed one coulomb of electricity (one ampere flowing for one second) deposits 0.00118 grams of silver,0.00065 grams of copper. Since each ion of silver is deposited by accepting one electron and the charge carried by each electron is 1.602×10^{-19} coloumbs, the number of electron in one coluomb would be =

$(1 / 1.602 \times 10^{-19})$ and these would be accepted by $(1 / 1.602 \times 10^{-19})$ ions of silver and these number of atoms must weigh 0.00118 grams.
Therefore 108 grams of silver will have

$108 / 1.602 \times 10^{-19} \times 0.00118 = 6.02 \times 10^{23}$ atoms. This number is known as Avogardo's number.Therefore

6.02×10^{23} atom or molecules or ions represent one mole of any element or a compound and their masses are atomic masses expressed in grams.

Gram molecular Volumes: The volume occupied by one mole of any subtance, if it can be converted into vapour or if it can exist as a gas at normal temperature ($0^{\circ}C$ or 273 K) and one atmospheric presure, is always 22.4 liters (assuming ideal behaviour of course)

Experimental determination shows 22.4 liters of hydrogen at NTP weighs 0.2 grams, 22.4 litres of oxygen weighs 3.2 grams, 22.4 liters of ammonia weighs 1.7 grams and so on. Therefore 2 grams of hydrogen, 32 grams of oxygen,

17 grams of ammonia will occupy 22.4 liters at NTP. Since these weights represent one mole of these substance, we can conclude that 22.4 liters of any gas at NTP will have Avogardo's number of molecules in them. This also explains why gases conbine with each other in simple volume ratio (Gay-Lussacs law of volumes)

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DEMONSTRATION EXPERIMENTS IN CHEMISTRY

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1. Products of Combustion: Apparatus as shown in the diagram is set up. A candle is lighted and the products of combustion are succtioned, water is condensed in the first test-tube and the lime water turns milky in the second showing water and carbon dioxide are the products of combustion, carbondioxide so formed is amjor pollutant.(figure 1)

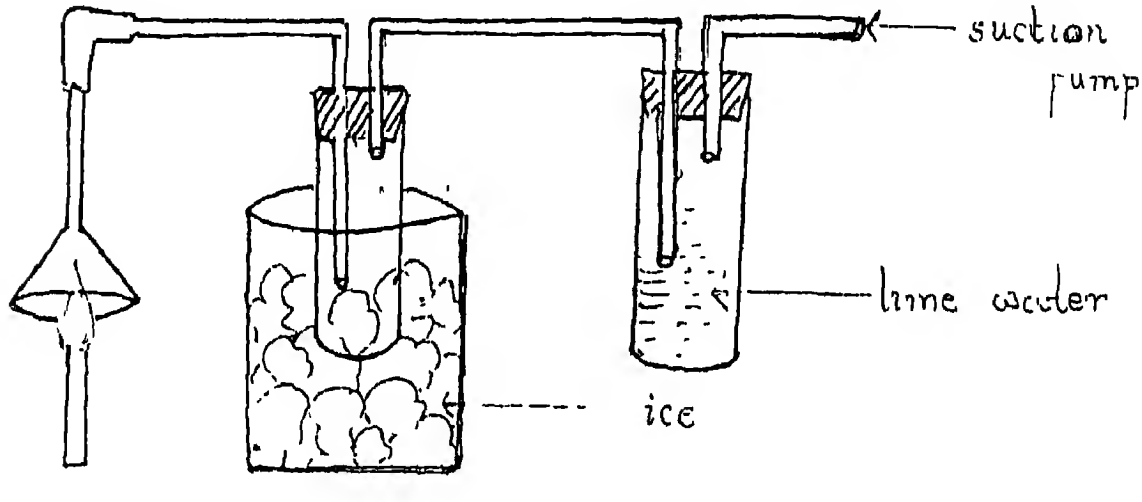

Fig - 1

2 To prove air contains 1/5th its volume of oxygen

Materials required: Two candles of same size, two bottles of different size, a tray, KOH solution.

The tray with the two candles fixed in it as shown in the (figure2) is filled to about half its height with KOH solution . The candles are lighted and the bottles are inverted over them. The candles burn for different lengrhs of time but the rise in KOH solution when the candles are put off in the two bottles are 1/5th the height of the bottle.

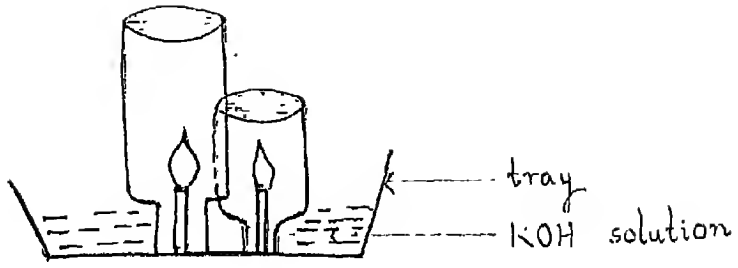

Fig-2

3. To prove prsence of moisture (water vapour), dust particles and CO in the atmosphere.

Apparatus required: Calcium chloride, guard tube, U-tube, sucction pump (figure 3)

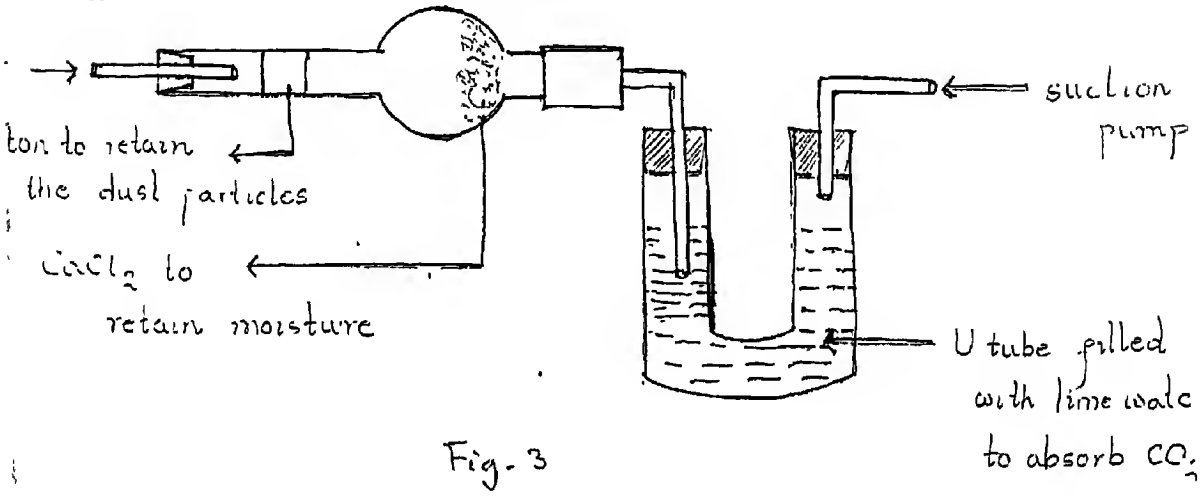

Fig-3

4. Synthesis of water: Zinc will react with dilute HCl and hydrogen will be produced which will burn in air to form water. The water so formed will condense on the outer wall of the round bottomed flask.(figure 4)

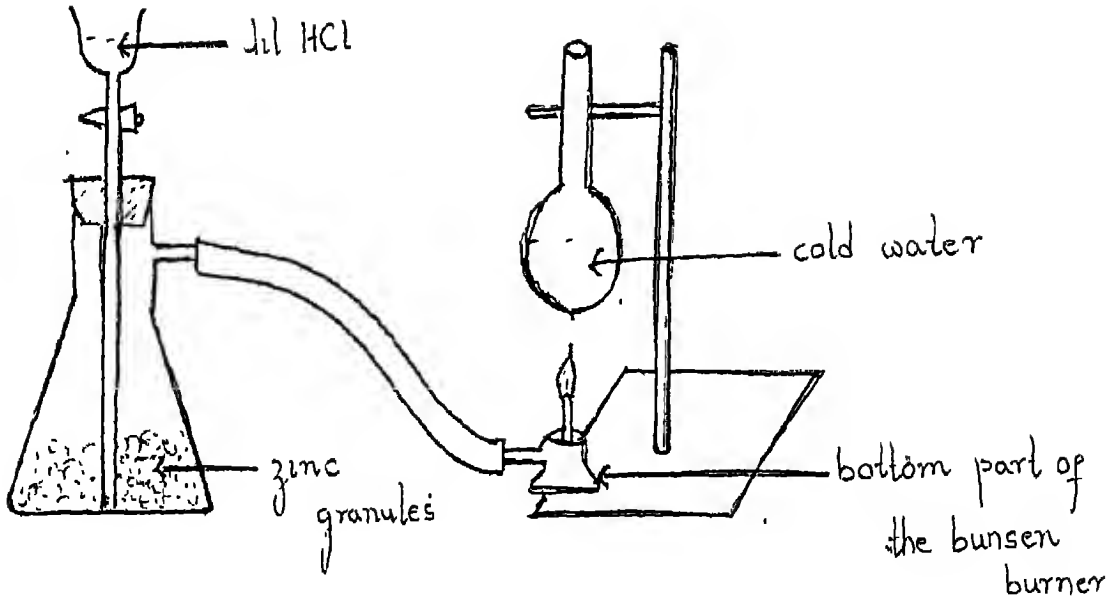

Fig-4

5. Various combinations of metals and their salt solutions can be taken to demosntrate the electro chemical series and activity of different metals.(fig 5)

5

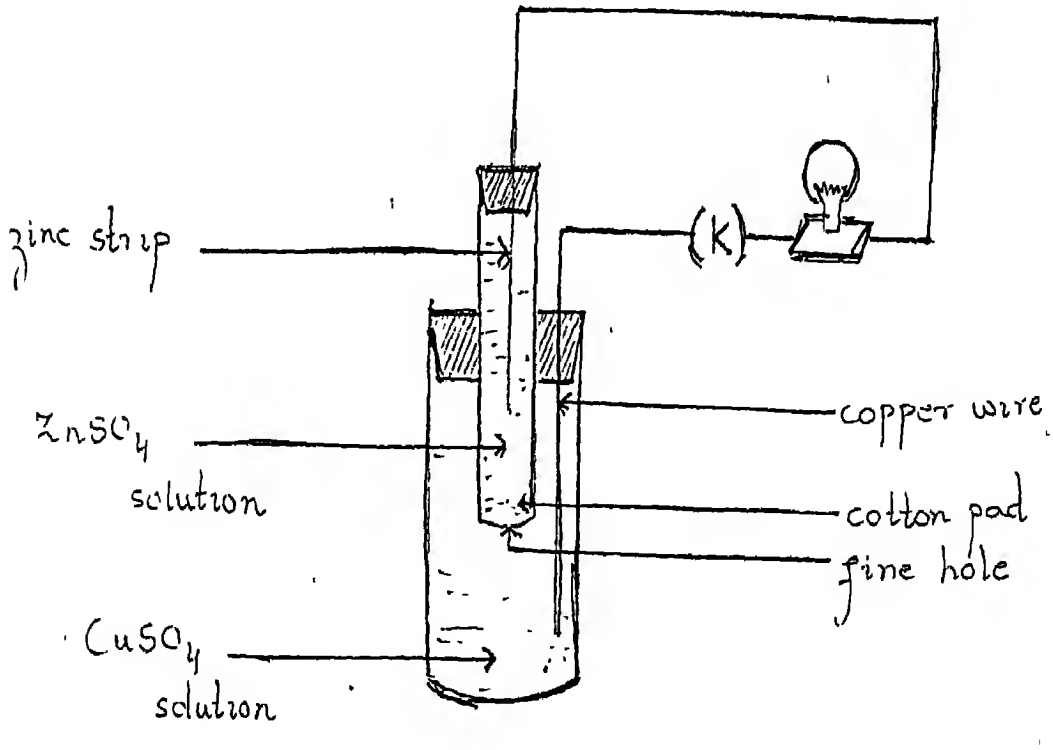

Fig-5

6. Clasification of compounds:

(a) Test of hardness ---------- hard or soft
(b) Heating in a test-tube---------- melts or not
(volatile/nonvolatile
(c) treatment with water ---------- Soluble in water or not
(d) conductivity ----------conductor or non-conductor in solid state or in solution.

Materials required: Salts sugar, sulphur, wax, metal foils or strips, saw dust.

7. To distinquish unsaturation in aliphatic and aromatic compounds.
Smaple chosen: (a) Acetylene (carbide gas) - prepared by reaction of calcium carbide with water in a test-tube fitted with a delivery tube- passed through bromine water taken in another test-tube.
Brown colour of bromine-water is discharged due to addition of bromine to acetylene at the site of unstauration.

(b). Benzene added drop by drop to bromine water taken in a test tube.No change of colour since there is no reaction.

(c). Benzene when burnt on a copper-foil. sooty flame is observed with a lot of unburnt carbon.

8. To distinguish a crystalloid from a colloid:
Sample chosen:

(a1) Sodium chloride (common salt) when dissolved in water forms a solution>(Homogenous mixture containing Na and Cl ions.

(a2) Sodium chloride when put into benzene (or kerosene) forms a turbid suspension - sodium chloride does not ionise - remains in colloidal form.

(b) soap powder added to spirit forms solution (homogeneous mixture)

(c) Soap powder added to water - forms a lather colloidal suspension..

METALS AND NON METALS

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General: Of the hundred and odd elements known more than eighty are metals. Each element has its own characterstics, Metals as a set of elements, have some general characterstics which differentiate them from rest of the elements(i.e.nonmetals). Although it is not that easy to draw a sharp line of distinction between a metal and a non-metal, a few prominent properties (both physical and chemical) can distinguish them from each other. A few border-line elements areknown as metalloids (e.g.As, Sb,Bi).

CONCEPTS:

1. Elements can be broadly classified into metals and non-metals; a few being metalloids.
2. The observed physical properties of metals can be explained on the basis of metallic bonds.
3. The chemical properties of metals are different from those of non-metals and the relative reactivity of metals can be explained taking help of the electrochemical series(metal activity series)
4. Methods of extraction of metals depend upon the nature of their ores.
5. Metals and alloys find many uses in our daily life.

A study of the periodic table indicates that in any one horizontal row, there is alomost a regular change from metallic character from the left to the right. Similarly within one vertical column, there is regular change from non-metallic character of elements to metallic character.

General Characterstics of Elements:

Although the metals show a great diversity of properties, there are some general characterstics which distinguish them from the non-metals;

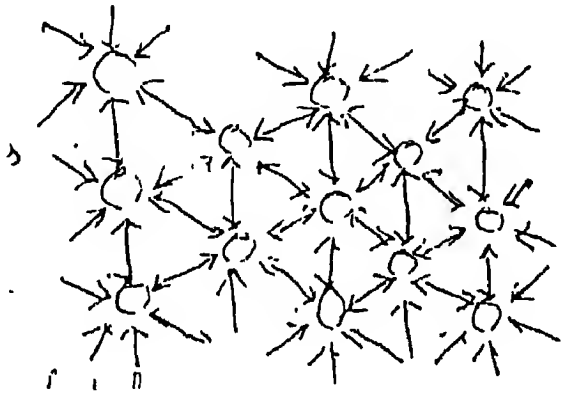
1. PHYSICAL PROPERTIES

a. they are good electrical conductors.
b. they are good thermal conductors.
c. they have lustre on freshly cut/broken surface
d. they have closed packed arrangements of atoms and therefore tend to have relatively high densities.
e. they change shape without cracking, under strain and so are malleable and ductile, in spite of the fact that

their atoms hold strongly to one another.
f. they possess high m.p & b.p
The above observed physical properties of metals cannot be explained on the basis of covalent and ionic bond models.

Let us examine the structure of metallic atoms
i) They have a few valence electrons and a number of vacant orbitals.
ii) They have low ionization energies.

When atoms of a metallic element are brought together they readily lose one or more valence electrons which can freely move into vacant valence orbitals of neighbouring atoms. On a collection of atoms, we can imagine the atoms are +vely ionized which are submerged in a sea of electrons. This model is known as Metallic bond model.



Let us now see how the metallic bond model may be used to explain the physical properties of metals.

(a) &(b) THERMAL AND ELECTRICAL CONDUCTIVITY

On heating an iron rod at one end ,the atoms gain energy and vibrate rapidly. Consequently, the electrons also move about with more energy within the crystal lattice of the metal. Some of this energy can be rapidly transported to the end of the rod. During conduction of electricity through a metal (copper wire), the mobile or delocalized electron shifts from one atom to another on account of its freedom to move.

(c) LUSTURE AND COLOUR:

Finely divided metals appaer to be brown or black. Presence of metallic bond gives this property . The incident light (considered as a form of enegy) increases the kinetic energy of the delocalized electron which is passed on to kernel of the atom, which in trun moves

more rapidly , but at random. This results in the absorption of light of all wave lengths and causes the black appearance of the metal.
In polished surfaces of the metals, the light is absorbed and emitted with change in direction. The metals in general appear to be silvvery grey
(d) & (e) HARDNESS, MALLEABILITY & DUCTILITY

As stated earlier, the structure of metallic crystals suggest that in such a crystal, there is a sea of delocalized electrons and that the positively charged metal ions are clustered in it.When a metal is stretched or beaten, the ions move in the direction of the force applied and the metal changes its shape to a wire or a sheet, without breaking. During this aarrangement, the vacant places or imperfections in the crystal structure are removed and the metal becomes harder, while bending a metal wire or sheet,some ions are separated from the adjacent delocalized electrons and nearest ion neighbours to disturb or break the crystal pattern. Even though these break in the pattern may not be visible as cracks, yet they represent regions of irregular joining of crystals.
No further attempt can put these crystals into original shape and form because the planes and edges formed during bending do not fit in again to form the original crystal pattern.

(f) MELTING AND BOILING POINT:

Sodium is a soft metal and its m.p & b.p are relatively low where as magnesium and aluninium are hard and of lighter m.p & b.p . This can also be explained on the basis of metallic bond model.
The bond between two soodim atoms in a sodium crystal is only one eighth of a covalent bond because the sdium crystal is body centered cubic in shape in which each atom is sorrounded by eight other atoms. The bond between two adjacent atoms is relatively weak and is responsible for the low m.p and b.p . Similarly, less force of attaction between its atoms in the crystal lattice gives low density to sodium and is responsiible for its softness.

On the other hand, magnesium has twelve neighbours in its crystal lattice. With two valence electrons to share among these twelve neighbours , the bond between two atoms may be considered approximatelly one sixth of a covalent bond. Thus in comparison to sodium the stronger bonding of atoms in solid magnesium accounts for its higher m.p The stronger interatomic attration gives greater density and hardness to megnesium than sodium . It is also less compressible.

In case of aluminium the atom has twelve neighbouring

atoms in its crystal lattice with three valence electrons to form stronger bonds (i.e. one fourth of the covalent bond) Therefore it has higher m.p & b.p and is of greater hardness.

In this way the nature of the metallic bond helps in explaining the gradation of physical properties of metals in a given period or group of the periodic table.

2 CHEMICAL PROPERTIES:

a. In chemical reactions metals act as electron donors to form positive ions, This is related to the ease with which the metal atoms lose electrons and also because there are usualy less than four electrons in their outer energy levels.
b. They form basic oxides (some also form amphoteric oxides)
c. They form highly ionic halides.
d. Active metals form hydrides and carbides.

REDOX REACTIONS

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Redox reactions deal with the oxidation and reduction reactions occuring in both homogeneous and hetrogeneous systems. The participants were explained the basic difference between the redox ractions and other type of reactions like decomposition reactions or preceipitation reactions. Using suitable examples, it was explained to them that in redox reactions, two reactions occur simultaneously. Electrons are released in one reaction and they are consumed in the other reaction. Both the reactions must occur simultaneously.

Futhermore, they were impressed that oxidation of any substance can occur only when there is another substance which can accept the liberated electrons. And if there is no such substance, the oxidation processs cannot proceed. Similar applies to the reduction process.

As mentioned earlier also, redox processses occur in both homogeneous and heterogeneous systems. Taking the following reactions as example,

$$Zn + Cu^{++} \longrightarrow Zn^{++} + Cu$$

$$Zn + 2H^{+} \longrightarrow Zn^{++} + H_2$$

it was explained that the basic processes in both cases involve release and acecptance of the electrons. Furthermore, each redox process is a combination of reduction reaction and oxidation reaction irrespective of the condition under which the process occurs. The participants were told that free electrons are not released in agueous solution and therefore, it is not possible to have oxidation reaction alone by releasing electrons into the solution.

Galvanic cells and their formation under different conditions was also discussed at length. Discussion of galvanic cells in this unit was essential since elcetric current is generated in galvanic cells due to occurance of redox reduction, occuring separately at the two electrodes.

Formation of galvanic cells on combination of two different metals was also explained. A number of simple examples were taken for expaining the formation of these cells and how electric power is generated due to release

of electrons at one eelectrode and acecptance at the other. Polarity sign of the electrodes was clarified by considering the redox reactions occuring at the two electrodes in the cell. Significance of electrochemical series in predicting the nature of the metal dispacement reaction and the magnitude of e.m.f of the cell was also highlighted.

Redox reactions occuring in the dissolution of metals and during their corrosion in aquesous solutions were also taken up. Mthods of checking metal corrosion were also discussed. Advantages of electroplating and other types of protective coatings at the metalsurfaces and their effectiveness were explained.

Besides the galvanic cells in general, specific galvanic cells which are currently in use, like Laclanche cell, Daniel cell and standard cells, and the chemical processes occuring in them were also taken up. Special mention was made of the merits and demerits of these cells.

Working of lead accumulator which is the most widely used electrochemical source of power was discussed. Reactions occuring during charge and discharge stages were explained. Other secondary batteries like Zn-Cd battery and their limitation and advantages over the lead accumulator were also told.

Besides covering the subject matter and clarifying the doubts, certain demostration experiments were performed. These experiments were subsequently repeated by the participants also. The follwoing experiments were carried out

1. Meausrement of dissolution rate of metals.
2. Measurement of e.m.f of galvanic cell
3. Effect of electrolyte concentration on e.m.f of galvanic cells.

The materials required for conducting the demonstration experiments are as follows:

1. Al, Fe, Mg, and Cu metal plates.
2. Sulphuric, Hydrochloric and Nitric acid and and other salts.
3. Boiling point tube fitted with a micropipette.
4. Voltmeter range 0 to 5 volts.
5. Connceting wire
6. Crocodile clips.

Electrolytic Solutions

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This unit deals with the properties of solutions specially of those substances which are known as electrolytes. There are two types of substances. Those which produce ions on dissolving in water and those which do not produce ions. The former category is known as electrolytes and the later type is called non-electrolytes. This difference arises due to the nature of the subtance in the solid state. The electrolytes consist of ions even in the solid state and when they are dissolved in water, the ions become free. But the non-electrolyte are present in molecular/ atom form in solid state. On dissolution of non-electrolytes, ions are not generated. However, there are certain execptions due to the existance of certain compund which although present in molecular form in solid state, produce ions on dissolution. These substances are known as weak electolytes or pesudo electrolytes.

Although both strong electrolytes and weak electrolytes produce ions on dissolution due to the process of dissociation, the extent of dissociation is almost 100% in thr former but it is comparatively very low in the later. This property of dissociation into ions is represented in terms of degree of dissociation.

Due to the formation of ions in solution, solution of electrolytes are electrically conducting. the conductivity of solutions depends both on nature of the electolyte as well as the solvent. Water is the favourable solvent for producing highly conducting solution due to its high dielectric constant. The participants were explained the variations in solution conductivity with concentration and temperature. Effect of concentration on conductance was clarified to them in light of the variation in mobility of ions and their size. Certain experiments were also shown to demonstrate the variation in solution conductance with nature of the salts. their concentration and the solvent type.

The property of electrical conducatnace of the electrolytes solutions has lead to development of the process of electodeposition. In this process, a metal is deposited electrically by passing electrical current

deposition is to occur, is made cathode . Anode is made of the metal which is being deposited at the cathode e.g.in the electrodeposition of copper on copper sheet, both anode and cathode are of copper metal but copper substrate at which depostion is to occur is made cathode. The following electro- chemical reactions occur at the two electrodes.

At anode $Cu \longrightarrow Cu^{++} + 2e^{-}$

AT cathode $Cu + 2e^{-} \longrightarrow Cu$

The electrolyte solution needed for this process contains copper sulphate and sulphuric acid. The rate of deposition depends upon d.c current passing through the solution between the two electrodes. Further more, nature of the deposit very much depends on composition of the solution. By adding different additives into the solution, deposit can be made shining or mattty type.

The process of electodeposition was shown to the participants. Electrodeposition of copper was carried out on steel and copper sheets.

Materials required for the Experiment.

1. 1.5 volt dry cell --- 4 numbers.
2. Copper suphate solution
3. Sulphuric acid
4. Sodium chloride
5. Rheostat
6. Ammeter 0 - 2 amp
7. Connceting wire
8. Crocodile clips.

Advantages of electrodeposition in providing protection against corrosion were also discussed. Elec trodeposition of various metals and polymers for decorative coating was explained e.g the electrodèposition of gold and silver is done to give a decorative coating. It is hoped, the participants will be able to show these experiments and make teaching more effective. Further it may be added that stress was given mainly in explaining certain difficult concepts and clearing their subject doubts.

CHEMICAL BONDING

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The basic unit of all the materials in this world is the atom. Except the noble gases, which are monoatomic, the atoms exist in the combined form in most of the matter either as discrete molecules (H_2, CO etc) or cluster of ions (NaCl, metals etc) or as giant net work of atoms (diamond, graphite). The atoms of noble gases have eight electrons (s p configuration) in the outermost orbit execpt He, are quite stable, do not combine (except Kr & Xe) while the atoms of other elements combine to form stable compounds. Thus the combination of the atoms causes lowring of energy. The force which is reponsible for the combination of the atoms is called chemical bond. In fact, a chemical bond is only a sort of inter atomic, inter molecular or inter-ionic attraction which holds the two atoms or ions together. the nature of a chemical bond depends on the nature of the elements to combine. Broadly the elements in the periodic table are classified as electropositive (metallic) or electronegative (non-metallic) and the elements which are neither electropositive or electro negative (semi-metallic)

i) If the atoms of any electropositive elements combine, results in the formation of metallic bond

ii) The combination of atoms of only electronegative elements causes the formation of covalent bond.

iii) whereas the atoms of electropositive with electronegative elements give rise to the formation of Ionic bond.

These are the three major types of chemical bonding which are considered as the strong bonds.

Coordinate covalent bond is a special type of covalent bonding.

The Van der Waal's and the hydrogen bond are the weaker type of bonding. The bond energy of hydrogen bond and Van der Waals are 3-10 kcal/mole and 1 kcal/mole respectively, which are quite low in comparison to that of covalent bond (50 - 100 kcal/mole). Most of the chemical bonds are not 100% pure, except when it is an ionic bond between a strong electropositive and strong electronegative elements and a covalent bond between two elements having identical electronegativities.

In other cases if the electronegativity difference between the two elements forming a bond is intermediate between the above two, the bond exhibits a mixed

character.

For an electronegativity difference of 1.9 between the two atoms, the bond is 50% ionic in character. When the difference is greater than 1.9, the bond is correspondingly more ionic.

Ionic compounds and covalent compounds widely vary in both physical and chemical properties such as solubility, M.P., B.P., conductivity, chemical reactivity, etc..

PERIODIC CLASSIFICATION

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Chemistry is the knowledge of matters i.e elements . Till today there are all total about 106 elements are discovered having Atomic Number serially upto 106 and another element Eka-mercury with atomic number 110.

Necessity of Classification: It is just impossible for any indivdaul to memorise the physical and chemical properties of all these elements separately. So the necessity of the classification of the elements into different groups arises. Thus if any one of the element in a group is studied in detail then the study of other members in that group is found easy by comparison, in fact can be predicted with considerable accuracy

Basis of classification of elements: With the help of the periodic law proposed by Moseley which states that " the properties of the elements are the periodic functions of their atomic number", it is possible to study the chemistry of the elements systematically.

Classification: Many attempts were made to classify the elements in a systematic order. They are

(i) Dobereiner's triads
(ii) Newland's law of Octaves
(iii) Lother Mayer's group
(iv) Mendeleeff's periodic table
(v) Modern Longform periodic talbe.

including a number of modified charts and three dimensional models like globes, helices, cones, prisms, castles etc.

Modern Long form periodic table, which was designed by Bohr isthe most accepted one for the classification of the elements.

Main Fetures of the Long form periodic Table:

(i) There are 16 vertical columns called Groups. These are IA &IB, IIA & IIB, IIIA & IIIB .....VIII and zero group.The members of each group most often have same valence electron configuarations execpt for principa; quantum numbers.

(ii) The elements are mainly grouped as s, p, d & f block elements depending on which orbitals are being filled.
s- & p- blocks often called as the representative elements.

d- block elements are called - Transition elements.
f- block elements are known as Inner transition element

(iii) Horizontal rows are called Periods. There are seven periods and they include 2,8,8,18,18,32 elements respectively while 7th period is incomplete. the elements of atomic number 93 to 106 are called synthetic elements discovered during atomic research.

(iv) To avoid execessive elongation of the periodic table the 14 elements (Lanthanides) that follow Lanthanum and the 14 elements (Actinides) that follow Actinium are placed in separate rows at the bottom of the table.

(V) Periodic Properties: Some of the fundamental properties of the elemtns like Ionisation potential, electron affinity, electronegativity and atomic size are the consequences of the electronic configurttions of the elements. And the variations of such properties reflect the general nature of the elements. The elements are broadly classified as metals, semimetals and non-metals.

The elements that are found in the lower and left hand regions of the periodic table have low ionisation energies, fairly large atomic radii and electropositive in nature are metals. Metallic properties tend to decrease from left to right along a row of the periodic table. the upper right hand area of the periodic table includes non-metallic elements. The atoms of these elements have high ionisation energies and high electron affinities. The atomic size decreases gradually from left to right along the period execpt that of the noble gas atoms , as the Van der Waal radii are taken as the measure of the noble gas atomic size whereas covalent radii are used for rest of the elements.

The semimetallic elements lie as a diagonal band that runs through the periodic table from boron to tellurium. Their fundamental properties are intermediate between the metallic and non-metallic elements.

SOURCES AND USES OF ORGANIC COMPOUNDS

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The division of chemistry into organic and inorgnic has its origin in earliest antiquity. Many organic copounds like alcohol, sugar, fats, soap, vinegar, indigo and starch were known to prehistoric people. In 18th century many organic compounds isolated from natural sources..scientists obtained tartaric acid, citric acid and malic acid from grapes, lemons and apples respectively. He also prepared lactic acid from sour milk, oxalic acid by oxidation of sugar with nitric acid and glycerol from animal fats. Urea was obtained from urine and alkaliod morphine from opium. It was Berzelius who first named the substance derived from living organisms (plants or animals) as organic compounds and there came into existance organic chemistry. In other words compounds of carbon are known as organic compounds.

Sources of organic compounds are divided into two main branches i.e. natural and laboratory synthesis. Natural sources is again divided into plant and animal sources.

About 40 years back the main sources of organic compounds were the processes of fermentation and wood distillation while fewer compounds were derived from coal and petroleum. Major organic compounds nowadays are obrained from synthesis.

Nowdays petroleum is one of the biggest source of organic compounds.

The crude petroleum obtained from the earth is subjected to fractional distillation and is used as follows:

1. Gaseous fraction-- Gases -- fuel gas
2. Naphtha or light oil fraction cymogene - ice manufacure.
   Riggoline - medicine
   Petroleum Ether - Extraction of oil and fats
   Petrol (gasoline)- Fuel for internal combustion Engine
   Benzene - Solvent for dry cleaning
3. Kerosene oil fraction - Kerosine oil -Illuminating purpose.
4. Heavy oil fraction - Fuel oil or gas oil - fuel for disel engine
   White oil- cheap scents,oil & medicinal oil
   Lubricating oil (Mineral oil) - machines
   Vaselin or Grease - Lubricating, medical,ointment,cosmetics.

Paraffin wax - Candle, coated paper etc

Since we are getting a number of products from these fractions, it is regarded as the main source of carbon compounds.

Uses: There is no art, science or industry where a knowledge of organic chemistry is not applied.

(1) Application of daily life:

a. Food - starch, fats, proteins, vegetables etc.
b. Clothes - cotton, wool, nylon and acron
c. Fuels - Coal, kerosene, diesel oil, petrol,
d. Leather and wood products.
e. Rubber and plastics - poly ethylene, polystyrene
f. paints and varnishes.
g. dyes of all kinds.
h. Medicines - penicillen, streptomycin, antibiotics
i. cosmatics
j. Insceticides - D.D.T, Gamnxene
k. Explosives
l. Stationary - pencil ,paper, writing ink

(2) Application in industry

(3) Study of life processes.

Some of the chemicals that can be synthesised are:

Cyclohexane - Adipis acid -Synthetic fibres
Benzene - phenol - Toluene
Benzene - Xylene - Terepthalic acid

All thes compunds are very useful in our daily life.

THE ACCURACY OF APPROXIMATE CALCULATIONS

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1. Introduction : Since applied mathematics comes down ultimately to numerical results, the worker in appled mathematics will encounter all kinds of numbers and all kinds of formulas. He must be able to use the numbers and evalute the formula so as to get the best possible result in any situation. What he learned about numerical calculation in his earlier study of arithmetic is inadequate for handling the numerical side of applied mathematics. For exampl, the numercial data used in solving the problems of everyday life are usually not exact and the numbers expressing such data,are therefore not exact. They are merely approximations, true to two, three or more figures.

Not only are the data of practical problems usually approximate, but sometimes the methods and processes by which the desired result is to be found are also approximate. An approximate calculation is one which involves approximate data, approximate methods or both.

It is therefore evident that the error in a computed result may be due to one or both of two sources: errors in the data and errors of calculation. Errors of the first type cannot be remedied, but those of the second type can usually be made as small as we please. Thus when such a number as Pai is replaced by its approximate value in a computation, we can decrease the error due to the appoxiamation by taking pai to as many figures as desired, and similarly in most other cases.

The object of the present discussion is to set forth some basic ideas and methods relating to approximate calculations and to give methods for estimating the accuracy of the results obtained.

2. APPROXIMATE NUMBERS AND SIGNIFICANT FIGURES

(a) Approximate Numbers: Numbers as 2, 1/3,100 etc, are exact numbers because there is no approximation or unccertainity associated with them. Although such numbers as pai, $\sqrt{2}$, e, etc are exact numbers. They cannot be expressed exactly by a finite number of digits,when expressed in digital form, they must be written as 3.1416, 1.4142 2.7183 etc. Such numbers are therefore only approximation to the true values and in such cases are called approximate numbers. An approximate number is therefore defined as a number which is used as an approximation to an exact number and differ only slightly from the exact number for which it stands.

(b) Significant Figures: A significant figure is any one of the digits 1,2,3 .....9 and 0 is a significant figure except when it is used to fix the decimal point or to fill the place of unknown or discorded digits. Thus, in the number 0.00263 the significant figures are 2,6,3; the zeros are used merely to fix the decimal point and are therefore not significant. In the number 3809, however, all the digits, including the zero are significant figures. In a number like 46300 there is nothing in the number as written to show whether or not the zeros are significant figures. the ambiguity can be removed by writing the number in the powers of ten notation as 4.63×10^4, 4.630×10^4, or 4.6300×10^4 the number of significant figures being indicated by the factor at the left.

3. Rounding of Numbers

If we divide 27 by 13.1, we get 27/13.1 = 2.061068702 ..... a quotient which never terminates. In order to use such a number in a practical computation, we must cut it down to a manageable form, such as 2.06 or 2.061 or 2.06107 etc. This process of cutting off superfluous digits and retaining as many as desired is called rounding off.

To round off or simply round a number is to retain a certain number of digits, counted from the left and drop the others. This is attained by rounding off acording to following rule.

To round off a number to n significant figures, discord all digits to the right of the n th place. If the dicorded number is less than half a unit in the n th place, leave the n th digit unchanged, if the discorded number is greater than half a unit in the n th place, add one to the n th digit. If the discorded number is exactly half a unit in the n th place, leave the n th digit unaltered if it is an even number, but increase it by 1 if it is an odd number in such cases.

When a number has been rounded off according to the rule just stated, it is said to be correct to n significant figures.

The following numbers are rounded off correctly to four significant figures.

29.63243	becomes	29.63
81.9773	become	81.98
4.4995001	becomes	4.50
11.64489	becomes	11.64
48.365	becomes	48.36
67.495	becomes	67.50

when the above rule is followed consistently, the errors due to rounding are largely cancelled by one another.

4.Absolute, Relative and Percentage Errors

The absolute error of a number, measurement or calculattion is the numerical differences between the true value of the quantity and its approximate value as given or obtained by measurement or calculation. The relative error is the absolute error divided by the true value of the quantity. The percentage error is 100 times the relative error. For example let Q represent the true value of some quantity. If

Q is the absoulte error of an approximate value of Q, then

$$\frac{\triangle Q}{Q} = \text{relative error of the approximate quantity.}$$

$$\frac{100\,\triangle Q}{Q} = \text{percentage error of the approximate quantity.}$$

If a number is correct to n significant figure, it is evident that its absoulte error cannot be greater than half a unit in the n th place. For example, if the number 4.629 is correct to four figure, its absolute error is not grater than 0.001 x 1/2 = 0.0005.

SURDS

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1.Introduction: We know that the numbers like 2/7, -4/5 etc, which can be expressed as a ratio of two integers are called rational numbers and the numbers like $\sqrt{2}$, $\sqrt[3]{5}$, etc which cannot be expressed as ratio of two integers are called irrational numbers. But the nature of a number like $\sqrt{2}$ is different from the nature of a number like $\sqrt{2+\sqrt{2}}$. A particular type of irrational numbers is called a Surd.

Definition: An irrational root of a rational number is called a Surd. Thus $\sqrt[n]{a}$ is a surd if (i) a is rational and (ii) the result $\sqrt[n]{a}$ is irrational. Hence $\sqrt{3}$; $\sqrt[3]{7}$; $\sqrt[4]{10}$ are surds. But $\sqrt{pai}$, $\sqrt{2+\sqrt{19}}$ are not surds because pai $2+\sqrt{19}$ are not rational. Also $\sqrt{9}$, $\sqrt[3]{27}$ are not surds because

$\sqrt{9} = \pm 3$, $\sqrt[3]{27} = 3$ and they are not irrational.

For the surd $\sqrt[n]{a}$, n is called the surd-index or the order of the surd and ' a' is called the radicand. The symbol $\sqrt{\ }$ is called the radical sign.

Note: Every surd is an irrational number but every irrational number is not a surd.

2. The Law of Surds: Since $\sqrt[n]{a}$ can also be written as $(a)^{1/n}$, the laws of surds follow directly from those of indiecs. They are

(1) For any positive integer n and a positive rational number 'a' , the radical n a is the positive nth root of a

$$(\sqrt[n]{a})^{n} = a$$

e.g., $(\sqrt[3]{5})^{3} = 5$

(ii) Suppose n a and n b are two radicals of the same order, then

$$(\sqrt[n]{a}\ \sqrt[n]{b}\ )^{n} = (\sqrt[n]{a})^{n}\ (\sqrt[n]{b})^{n} = ab$$

$$\sqrt[n]{a} \cdot \sqrt[n]{b} = \sqrt[n]{ab}$$

e.g $\sqrt{9}\sqrt{2} = \sqrt{18} = 3\sqrt{2}$

(iii) If n a and n b are two radicals of the same order then

$$\left(\frac{\sqrt[n]{a}}{\sqrt[n]{b}}\right)^{n} = \frac{(\sqrt[n]{a})^{n}}{(\sqrt[n]{b})^{n}} = \frac{a}{b} \quad ; \quad \frac{\sqrt[n]{a}}{\sqrt[n]{b}} = \sqrt[n]{\frac{a}{b}}$$

e.g. $\dfrac{\sqrt[3]{2}}{\sqrt[3]{3}} = \sqrt[3]{\dfrac{2}{3}}$

(iv) If m, n are positive integers, then for a positive rational number a

$$\sqrt[m]{\sqrt[n]{a}} = \sqrt[mn]{a} = \sqrt[n]{\sqrt[m]{a}}$$

e.g: $\sqrt[4]{\sqrt[3]{x^{12}}} = \sqrt[12]{x^{12}} = x$.

(v) If m, n are positive integers, then for a positive rational number a

$$\sqrt[n]{a^{m}} = (\sqrt[n]{a})^{m}$$

e.g $\sqrt[4]{8^{4}} = (\sqrt[4]{8})^{4} = 2^{4} = 16.$

By simplification of a surd $\sqrt[n]{a}$, we mean that (i) there is no factor under the radical sign which is the nth power of some number and (ii) the order of the surd (i.e. the surd index) is the samllest possible.

3.Pure Surds: A surd which has unity as its rational factor, the other factor being irrational, is called a pure surd.

e.g. $\sqrt{5}, \sqrt{3}, \sqrt[3]{5}$ are pure surds.

4.Mixed surds: A surd which has a rational factor other than unity, the other factor being irrational, is called a mixed surd

e.g. $3.\sqrt{5}$; $4.\sqrt[3]{4}$; $2.\sqrt[5]{10}$ are mixed surds.

5.Comparison of surds: To compare the magnitude of surds of different orders we change them into the surds of the same order.

The order is the L.C.M, of the orders of the given surds;

Example I: Which is greater $\sqrt[8]{12}$ or $\sqrt[4]{6}$

Solution: L.C.M of 8 and 4 is 8

Thus $\sqrt[8]{12} = \sqrt[8]{12}$ and $\sqrt[4]{6} = \sqrt[8]{6^2} = \sqrt[8]{36}$

clearly

$$\sqrt[8]{36} > \sqrt[8]{12}$$

$$\sqrt[4]{6} \quad \sqrt[8]{12}$$

6. Addition and Subtraction of Surds:

Surds having the same irrational factor are called similar surds or like surds.

For example $5\sqrt{3}$; $7\sqrt{3}$; have the same irrational factor. Therefore they are like surds. Since surds are real numbers, the distributive law holds

In symbols, if $\sqrt[n]{a}$ is a surd, then

i. $k\sqrt[n]{a} \pm l\sqrt[n]{a} \pm m.\sqrt[n]{a}$ is a surd then

ii. $k\sqrt[n]{a} \pm l.\sqrt[n]{a} \pm m.\sqrt[n]{a} = (k \pm l \pm m)\sqrt[n]{a}$

Thus using the distributive law, like surds can be added and subtracted.

7.Multiplication and Division of Surds:

A surd can be multiplied or divided by another surd of the same order (i.e. similar surd). In symbols

$$k.\sqrt[n]{a}.\ l\sqrt[n]{b}\ .\ m.\sqrt[n]{c} = klm\sqrt[n]{abc}$$

$$k.\sqrt[n]{a} \div l.\sqrt[n]{b} = \frac{k}{l}\sqrt[n]{\frac{a}{b}}$$

If the surds are not of the same order, they can be put in the same order. Then

$$k\sqrt[n]{a} \times l\sqrt[m]{b} = k\sqrt[mn]{a^m} \times l\sqrt[nm]{b^m} =$$

$$= kl\sqrt[mn]{a^m b^n}$$

$$k.\sqrt[n]{a} \div l\sqrt[m]{b} = k\sqrt[mn]{a^m} \div l\sqrt[mn]{b^n}$$

$$= \frac{k}{l}.\sqrt[mn]{\frac{a^m}{b^n}}$$

8.Rationalisation of surds:

(a). Monomial surd: A monomial surd or simple surd is one which contains a single term

e.g. $\sqrt{3}$ $\sqrt{5}$ $\sqrt[3]{75}$ respectively

(b). Binomial Surd: A binomial surd is one which contains two monomial surd or a monomial surd and a rational number

e.g. $\sqrt{3}+\sqrt{5}$; $\sqrt{7}+9$; $\sqrt{11}-8$ and so on

(c). Trinomial surd: A trinomial surd is one which consists of three terms at least two of which are nonomial surds

e.g. $\sqrt{3}+\sqrt{7}-\sqrt{8}$; $5+\sqrt{3}+\sqrt{6}$

when the product of two surds is a rational number, each is called the " Rationalising Factor"(RF) of the other.
e.g $\sqrt{x}+\sqrt{y}$ is the rationalising factor of $\sqrt{x}-\sqrt{y}$ because the product is $(x - y)$ which is a rational number

Again $3\sqrt{5} \times \sqrt{5} = 15$; therefore $\sqrt{5}$ is R.F of $3\sqrt{5}$

also $(\sqrt{5}+\sqrt{3})(\sqrt{5}-\sqrt{3}) = (\sqrt{5})^2 - (\sqrt{3})^2 = 5-3=2$

therefore $(\sqrt{5}-\sqrt{3})$ is a R.F. of $\sqrt{5}+\sqrt{3}$.

Example:

If $a = \dfrac{\sqrt{3}+\sqrt{2}}{\sqrt{3}-\sqrt{2}}$ and $b = \dfrac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$

find $\left(a^3 + b^3\right)$

solution:

$$a = \frac{\sqrt{3}+\sqrt{2}}{\sqrt{3}-\sqrt{2}} \times \frac{\sqrt{3}+\sqrt{2}}{\sqrt{3}+\sqrt{2}} = \frac{(\sqrt{3}+\sqrt{2})^2}{(3-2)}$$

$$= \frac{3+2+2\ 3.2}{1} = 5 + 2\sqrt{6}$$

similarly $b = 5 - 2\sqrt{6}$

But $a^3 + b^3 = (a+b)^3 - 3ab(a+b)$

NOW $a+b = 5+2\sqrt{6}+5-2\sqrt{6} = 10$

$$ab = \frac{\sqrt{3}+\sqrt{2}}{\sqrt{3}-\sqrt{2}} \times \frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}} = 1$$

$\therefore a^3 + b^3 = (10)^3 - 3 \times 1 \times 10 = 1000 - 30$

$= 970.$

EQUALITIES AND INEQUALITIES IN TWO VARIABLES

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We will consider ordered pair of real numbers. Any two real numbers form a pair. When the order of the pair is designated, we call it an ordered pair of real numbers. If x is the first real number and y is the second real number, we denote this ordered pair by writing them in parentheses with a coma separating them as (x,y). Note that the ordered pair (-5,7) is different from (7,-5).

The set of all ordered pairs of real numbers is called the number plane and each ordered pair (x,y) is called a point in the number plane. The number plane is the cartesian product R x R or R^2 according to our definitions in set theory.

We can identify R^2 with a geometric plane (two dimensional space). The method of coordinatising as we use today in R^2, is being attributed to French mathematician Rene DesCartes(1596-1650) who is credited with the discovery of analytic geometry in 1637.

A horizontal line is chosen in the geometric plane and is called the X- axis . A vertical line is chosen in the plane intersecting this X-axis and is called the Y-axis. The point of intersection of the x-axis and the y-axis is called the origin and is denoted by the letter O. A unit length is chosen for x-axis and another for y-axis. Positive and negative directions are also chosen on the axes.

1.2: Graph of an Equation

The graph of an equation in R^2 is the set of all points (x,y) in R^2 whose x value and y value when substituted in the equation satisfies it.

The set of all points (x,y) which satify the equation when properly identified and marked suitably on the plane is called the graph of the equation. We sometimes call the graph of the equation the locus of that equation. This graph in R^2 is sometimes called a curve. Unless otherwise stated, an equation with two unknowns, x and y, is considered an equation in R^2.

1.3: Linear Equalities and inequalities in two variables

We know how to draw the graph of a line. Now any line divides the plnae R^2 into two equal parts.(Fig.1)

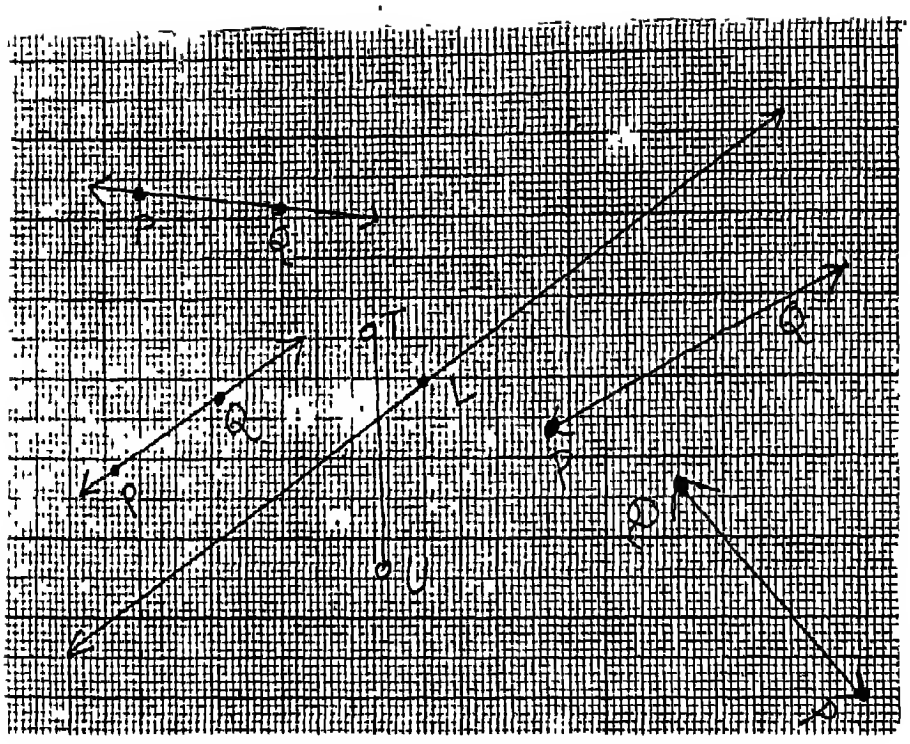


Figure 1

In figure(1) H_1 is the part of the plane say E lying above and to the left of the line L and H_2 is the part of the plane E that lies below and to the right of L. The sets of points in H_1 and H_2 constitute the two half planes.

Now take any two points P and Q in H_1. Then the segment PQ lies completely in H_1. The same thing happens if P and Q lies in H_2. The property that all points of the segment PQ lie in H_1 when P and Q lie in H_1 is described as that H_1 is a convex set. Similarly H_2 is a convex set. Of course the plane E and the line L are also convex sets. We notice, of course that if T belongs to H_1 and U belongs to H_2 then segement TU always intersects the line L.

Equation of any line is Ax+By+C=0 where A,B are not both zero. Any point (x,y) of the plane lying on the line (1) satisfy the equation

$$Ax + By + C = 0 \ldots\ldots\ldots\ldots (1)$$

This set of points form the solution set of (1). The solution set, therefore, contains infinite number of (elements)points of the plane.

1.4: Co-ordinates of a point lying on the segment PQ where coordinates of P and Q are given by $P = (x_1, y_1), Q = (x_2, y_2)$

Case i): Let A be the point in PQ dividing PQ internally

such that AP = k. AQ, k>0, $k \neq -1$. We draw PR and QR parallel to x-axis and y axis respectively through P and Q. Similarly we draw AE and AD parallel to x-axis and y-axis respectively.

From similar triangles PAD and AQE

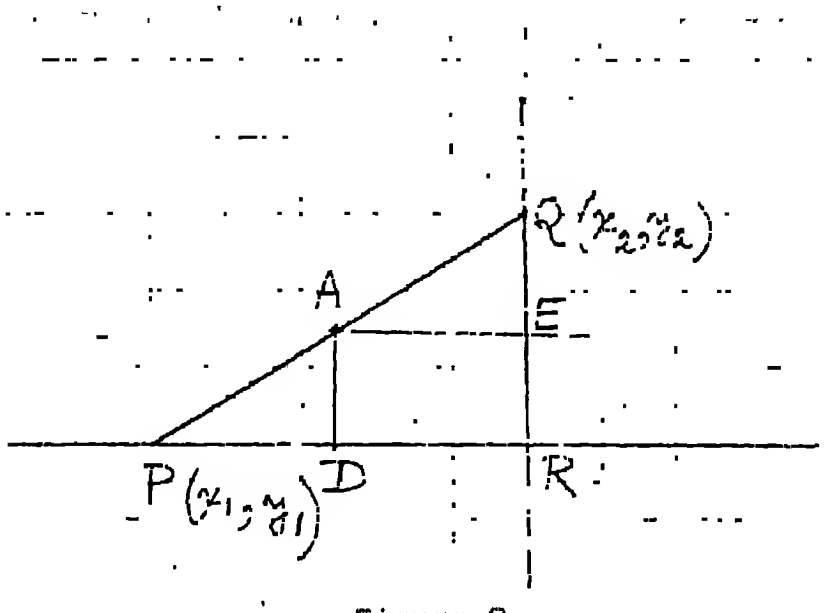


Figure 2

$$k = \frac{PA}{AQ} = \frac{PD}{AE} = \frac{AD}{QE}$$

If A ≡ (x,y), then PD = $x - x_1$, AE = $x_2 - x$

therefore $$k = \frac{x - x_1}{x_2 - x} \quad \text{or} \quad x - x_1 = k(x_2 - x)$$

$$x(1 + k) = x_1 + k x_2$$

$$x = \frac{x + k x}{1 + k}$$

$$x = \frac{x}{1+k} + \frac{kx}{1+k} = \alpha x_1 + \beta x_2$$

where $\alpha = 1/(1+k)$ and $\beta = k/(1+k) < 1$

that $0 < \alpha < 1$, $0 < \beta < 1$ and $\alpha + \beta = 1$.

Similarly we have $y = \alpha y_1 + \beta y_2$, $0 < \alpha < 1$, $0 < \beta < 1$ and $\alpha + \beta = 1$

So A has the cor-ordinates

$x = \alpha x_1 + \beta x_2$; $y = \alpha y_1 + \beta y_2$;

$\alpha = 1/(1+k)$, $k \neq 0$; $0 < \alpha < 1$, $0 < \beta < 1$; $\alpha + \beta = 1$

Case ii): Let A be a point on the line determined by P and Q but outside the segment PQ (Fig. 3)

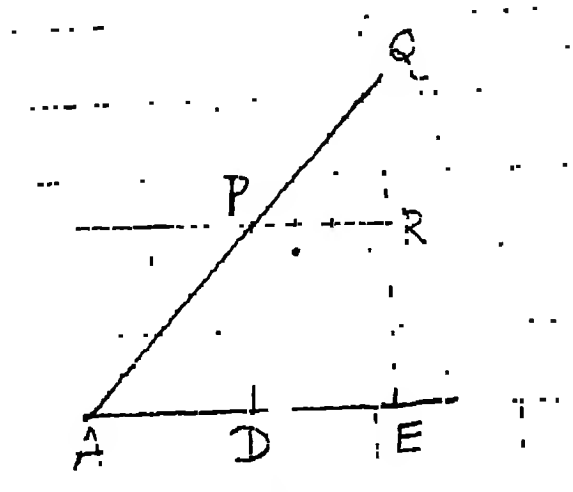


Figure 3

We draw the lines parallel to the corresponding axes through A,P and Q. Then triangles PAD and AQE are similar.Thus if

$$k = \frac{\overline{AP}}{\overline{AQ}} = \frac{\overline{AD}}{\overline{AE}} = \frac{\overline{PD}}{\overline{QE}}$$

k is positive as the ratio is positive.

$$k = \frac{\overline{AD}}{\overline{AE}} = \frac{x_1 - x}{x_2 - x}$$

or $k(x_2 - x) = x_1 - x$

or $x(1-k) = x_1 - kx_2$

$$\text{or } x = \frac{x_1}{1-k} + \frac{-k}{1-k} x_2 = \alpha x_1 + \beta x_2 .$$

$$k = \frac{\overline{PD}}{\overline{QE}} = \frac{y_1 - y}{y_2 - y} .$$ Similarly $y = \alpha y_1 + \beta y_2$

But in this case α & β are not necessarily positive. Of course

$$\alpha + \beta = \frac{1}{1-k} + \frac{-k}{1-k} = 1, \quad k \neq 1$$

If A is on the other side of Q and nearer to Q we get the same co-ordinates for A.

Note: If $k < 1$, the point A is nearer to P and if k is numerically greater than 1, the point A is nearer to Q.

1.5 We know that $(0, -c/B)$ & $(-c/A, 0)$ lie on

$$Ax + By + C = 0 \quad \ldots\ldots\ldots(1)$$

Let $P \equiv (0,-c/B) \equiv (x_1, y_1)$; $Q \equiv (-c/A, 0) \equiv (x_2, y_2)$ substituting x_1, y_1 and x_2, y_2 for x, y we get

$$\therefore \quad Ax_1 + By_1 + C = 0 \;\&\; Ax_2 + By_2 + C = 0 \quad \ldots\ldots\ldots\ldots(2)$$

where $x_1 = 0$, $y_1 = -c/B$, $x_2 = -c/A$, $y_2 = 0$

Then PQ determines the line (1) with (x_1, y_1) and (x_2, y_2) on (1). From (2)

$$0 = \alpha (Ax_1 + By_1 + C) + \beta (Ax_2 + By_2 + C)$$

$$0 = A(\alpha x_1 + \beta x_2) + B(\alpha y_1 + \beta y_2) + C(\alpha + \beta)$$

$$= A(\alpha x_1 + \beta x_2) + B(\alpha y_1 + \beta y_2) + C$$

for all real values of α and β

So also whenever $\alpha + \beta = 1$, α and β being real numbers. Hence the point $(\alpha x_1 + \beta x_2, \alpha y_1 + \beta y_2)$ lie on $Ax + By + C = 0$, where α and β are real numbers and $\alpha + \beta = 1$. There are infinite number of real numbers α, β with $\alpha + \beta = 1$. Therefore there are infinite number of points $(x = \alpha x_1 + \beta x_2,\ y = \alpha y_1 + \beta y_2)$

on $Ax+By+C=0$ if some (x_1, y_1) and (x_2, y_2) lie on (1)

1.6 Example: If 80 represents the standard charge in money for maintainice of installation and supply and if the electric company charges (1.25) unit of money for every unit of electricity then the cost y for consumption of x units of electricity will be given by

$$y = 80 + (1.25)\, x \quad \ldots\ldots\ldots(2)$$

Example: A Fahrenheit thermometer reads from 32 to 212 while the centigrade thermometer reads from 0 to 100. the temperature 32 F and 0 celsius and 212 F and 100 celsius measure the same degree of heat respectively. Therefore if the y F record the same heat as x C then

$$\frac{y-32}{(212-32)} = \frac{x-0}{(100-0)} \quad \text{or} \quad \frac{y-32}{180} = \frac{x}{100}$$

or $y - 32 = (9x / 5)$ or $y = 32 + (9x / 5)$ ...(3)

1.6(A): If a student has not been told about drawing a line in a plane then also he can find that

$$Ax+By+C=0 \quad \text{-----(1)}$$

has an infinite number of solutions.For this first we try to find $x=x_1; y=y_1$ and $x=x_2; y=y_2$, the two different solutions of(1). Then we give different values to α and β with the condition $\alpha+\beta=1$ and construct the set $\{\alpha x_1 + \beta x_2, \alpha y_1 + \beta y_2\}$ where $\alpha+\beta=1$}

Each point of the set is a solution of (1).As there are infinite number of real values α and β with $\alpha+\beta=1$ therefore the solution set of (1) is an infinite set.

1.6(B): Now let $A_1x + B_1y + C_1 = 0$

$$A_2x + B_2y + C_2 = 0 \qquad \text{--(I)}$$

be two linear equations in x, y. Can we find a solution of the system (I) always?

Case (i): If $\frac{A_1}{A_2} = \frac{B_1}{B_2} = \frac{C_1}{C_2} = k \neq 0$

then the first equation of (I) is $kA_2x + kB_2y + kC_2 = 0$ or

$$A_2x + B_2y + C_2 = 0 \quad \text{as } k \neq 0$$

Hence the system (I) contains only one equation as:

$$A_2x + B_2y + C_2=0 \quad \text{------(I)}$$

Therefore the system (1) has an infinite number of solutions as given in 1.6(A).

Note that in this case

$$\frac{A_1}{A_2} = \frac{B_1}{B_2} \quad \text{or} \quad A_1B_2 - A_2B_1 = 0$$

Case (ii) If $\frac{A_1}{A_2} = \frac{B_1}{B_2} = k \neq 0$ and $\frac{C_1}{C_2} \neq k$; $\frac{C_1}{C_2} \neq \frac{A_1}{A_2} = \frac{B_1}{B_2}$

Then the system becomes

$$kA_2x + kB_2y + C_1 = 0$$

$$A_2x + B_2y + C_2 = 0$$

or

$$A_2x + B_2y + (C_1/k) = 0$$

$A_2x + B_2y + C_2 = 0$ and $(C_1/k) \neq C_2$

or

$$A_2x + B_2y = -(C_1/k), A_2x + B_2y = -C_2$$

$$-\frac{C_1}{k} \neq -C_2$$

Hence in this case the same left hand expression is equal to two different quantities on the right.Thus the system (I) has no solution for x and y in this case.

When the students are familiar with the equation of lines in geometry then they observe that the equations in (I) in this case represent two parallel lines in the Euclidian plane.Since parallel lines donot intersect in this case the system(I) has no solution for x and y.Observe that

$$\frac{A_1}{A_2} = \frac{B_1}{B_2}$$

implies that $A_1B_2 - A_2B_1 = 0$ in this case also.

Case (iii): If $\frac{A_1}{A_2} \neq \frac{B_1}{B_2}$

then the system is equivalent to

$A_2 A_1 x + A_2 B_1 y + A_2 C_1 = 0$ --------(1)

$A_1 A_2 x + A_1 B_2 y + A_1 C_2 = 0$ --------(2)

obtained by multiplying the first equation by A_2 and second one by A_1

Now subtracting (2) from (1) we get

$$(A_2B_1 - A_1B_2)y + A_2C_1 - A_1C_2 = 0$$

or

$$y = \frac{A_1C_2 - A_2C_1}{A_2B_1 - A_1B_2}$$

and the values of x is

$$x = \frac{B_1C_2 - B_2C_1}{A_1B_2 - A_2B_1}$$

This pair of x and y i.e

$$x = \frac{B_1C_2 - B_2C_1}{A_1B_2 - A_2B_1} \quad \text{and} \quad y = \frac{A_2C_1 - A_1C_2}{A_1B_2 - A_2B_1}$$

form a solution of (I). This is the only solution of (I). The solution exists as real numbers as

$$\frac{A_1}{A_2} \neq \frac{B_1}{B_2} \quad \text{or}$$

$$A_1B_2 \neq A_2B_1$$

or $A_1B_2 - A_2B_1 \neq 0$ In this case the lines represented by (I) are not parallel. Hence they meet at exactly one point given above in the Euclidian plane. If we agree to write the equation as

$$A_1x + B_1y = -C_1$$
$$A_2x + B_2y = -C_2$$

and

$$A_1B_2 - A_2B_1 = \begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix} \quad \text{then}$$

$$A_1C_2 - A_2C_1 = \begin{vmatrix} A_1 & -C_1 \\ A_2 & -C_2 \end{vmatrix}$$

$$B_1C_2 - B_2C_1 = \begin{vmatrix} -C_1 & B_1 \\ -C_2 & B_2 \end{vmatrix}$$

and therefore $x = \dfrac{\begin{vmatrix} -C_1 & B_1 \\ -C_2 & B_2 \end{vmatrix}}{\begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix}}$; $y = \dfrac{\begin{vmatrix} A_1 & -C_1 \\ A_2 & -C_2 \end{vmatrix}}{\begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix}}$

Finally we have the following :

1) If $A_1B_2 - A_2B_1 = 0 = \begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix}$

then either (a) the system (I) has an infinite number of solutions for x and y. (case(i))
or (b) no solution at all (case(ii))

2) If $A_1B_2 - A_2B_1 = \begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix} \neq 0$

then the system has a unique solution given by (3) above.

1.6(C) Let
$$\begin{aligned} A_1x+B_1y+C_1 &= 0 \\ A_2x+B_2y+C_2 &= 0 \qquad \text{(II)} \\ &\cdots\cdots\cdots \\ A_mx+B_my+C_m &= 0 \end{aligned}$$

has m equations. where m ≥ 3

First two equations are chosen .We find the value of

$$\begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix} = A_1B_2-A_2B_1$$

Two cases arise :

Case(i): $A_1B_2-A_2B_1 \neq 0$ Then we find the solution for x,y as given in (3) above and substitute these values of x and y in all the remaining equations.

If these values of x and y satisfy each of the remaining equations of the system (II) then these

$$x = \frac{\begin{vmatrix} -C_1 & B_1 \\ -C_2 & B_2 \end{vmatrix}}{\begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix}}; \quad y = \frac{\begin{vmatrix} A_1 & -C_1 \\ A_2 & -C_2 \end{vmatrix}}{\begin{vmatrix} A_1 & B_1 \\ A_2 & B_2 \end{vmatrix}}$$

form the unique solution of the system (II).

If,however,these values of x and y do not satisfy at least one of the remaining equations of the system (II) then the solution set of system(II) is an empty set.

Case(ii)$(A_1B_2-A_2B_1) = 0$ Two possibilities arise.
(a) As in case (i) 1.6(b) the first two admit no solution for x and y. Therefore the whole system (II) has no solution for x and y.
(b) As in case (i) 1.6 (b) the first two equations are same. Then the system (II) becomes;

$$\begin{aligned} A_1x+B_1y+C_1 &= 0 \\ A_3x+B_3y+C_3 &= 0 \\ A_4x+B_4y+C_4 &= 0 \\ &\cdots\cdots \\ A_mx+B_my+C_m &= 0 \end{aligned}$$

and has one equation less than that in (II)
We now work with $A_1x+B_1y+C_1 = 0$
$A_3x+B_3y+C_3 = 0$
for finding the solution for x and y of the above system

Let $A_1B_3-A_3B_1 = \begin{vmatrix} A_1 & B_1 \\ A_3 & B_3 \end{vmatrix}$

If $A_1B_3-A_3B_1 \neq 0$

We go to 1.6(C) case(i) as done above and repeat the procedure as stated there to find the solution

If $A_1B_3-A_3B_1 = 0$ then we verify for case (a) above and get the results. If case (a) does not hold then (b) holds true. The system reduces furtehr by one more equation. Then the procedure is repeated again.

1.7: A point (x',y') does not lie on the line
$Ax + By +C \neq 0$ ..... (1)
Then x', y' when substituted for x and y in (1) does not satisfy the equation (1) i.e $Ax' +By'+ C \neq 0$.
As for example (18,20) does not lie on $y=80+(1.25)x$ since

$20 \neq 80+(1.25)18 = 80 +22.50$

or that (5,40) is not a point on $y = 32 + (9/5)x$ since

$40 \neq 32 + (9/5).5 = 32+9$

1.8: Let (x', y') be not a point on $Ax+By+C =0$. Then $Ax'+By'+C \neq 0$. This implies that either $Ax'+By'+C > 0$ or $Ax'+By'+C < 0$ i.e (x', y') satisfies one of the inequalities
$Ax + B y + C > 0$ or $Ax + By + c < 0$

Expression of the form $Ax+By+C > 0$, $Ax+By+C < 0$ $Ax+By+C \geq 0$, $Ax+By+C \leq 0$ where A and B are not both zero are inequalities of the first degree in x,y . By the graph of such an inequality, we mean the set of all points (x , y) in the plane, whose coordinates satisfy the inequality.

1.9: Let $Ax + By +C = 0$.....(1) be the equation of a line. Consider the coefficient B of y in (1)

Case (I) Suppose B=0. Then $A \neq 0$ and (1) becomes $Ax + C =0$ or $A (x + C/A)= 0$ or $x + C/A = 0$. We can always take $A>0$ (if need be by multiplying by -1).Then we plot the point $x = -c/a$ on the x-axis and through it draw a line parallel to the y-axis.(Figure 4).

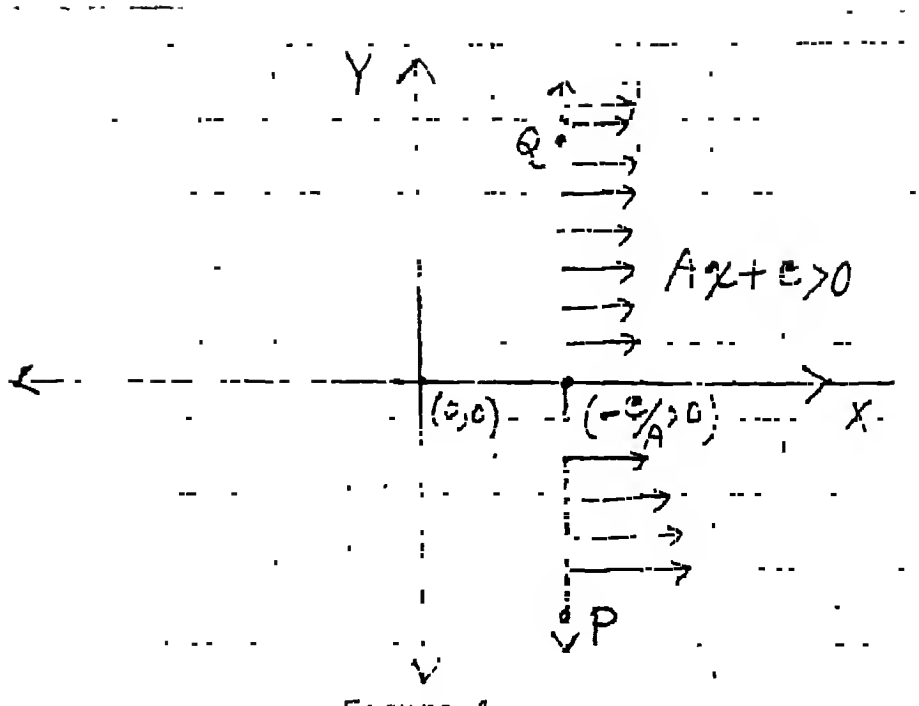


Figure 4

Then for every point (x,y) to the right of the line PQ i.e $x = -C/A$ or $x + C/A = 0$ or $Ax + C = 0$, we have $x > -C/A$ or that $Ax > -C$ (as $A > 0$) i.e $Ax + C > 0$. Also for every point (x,y) to the left of the line PQ i.e $Ax + C = 0$ we have $x < -C/A$ or $Ax < -C$ (As A) 0) or $Ax + C < 0$.

So if $A>0$ then $Ax + C=0$ divides the plane into two half planes. For all points in the right half plane H_1, $Ax+C >0$ and for all points in the left half plane H_2, $Ax + C < 0$. All points of H_1 satisfy the same condition $Ax+ C > 0$. Hence we search for a suitable point (x_1,y_1) in right half plane for which calculation of $Ax +C$ will be easy. If $Ax +C>0$ then for all points in H_1, $Ax+c>0$. Similarly for points in H_2.

Case II: $B \neq 0$. We can always arrange to make $B>0$ (if $B<0$, then multiply the equation (1) by -1) From (1)
$y = -(A/B)x - C/B = mx + D$ say .....(2) where $m = -(A/B)$ and $D=-C/B$.(Fig 5)

(1) $m>0$, $D>0$

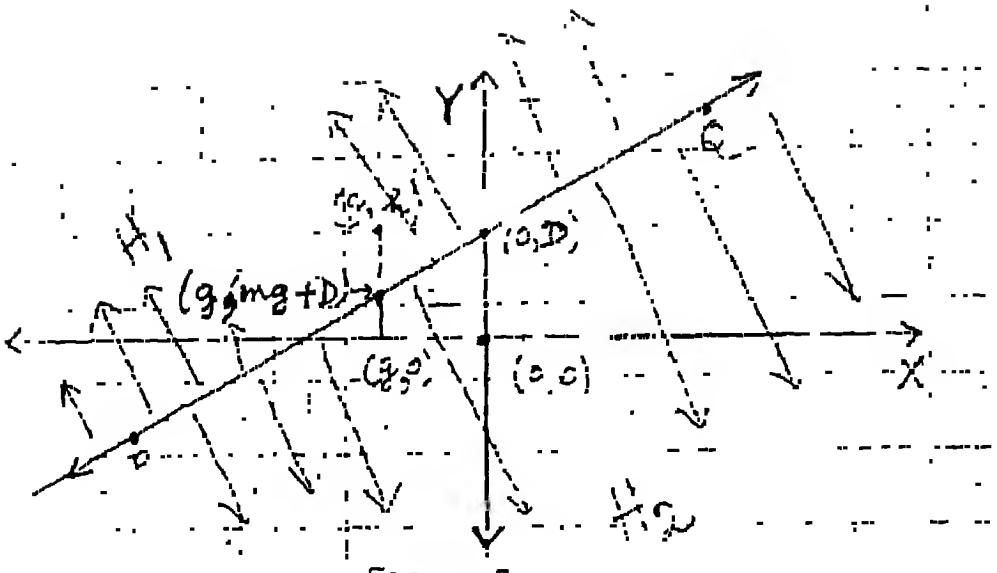


Figure 5

The graph of the line (1)or (2) will be like PQ as shown above.The line PQ divides the plane into two half planes H_1 and H_2 as shown in the figure 5. Let (g,h) be any point in the plane.When x=g,the corresponding y-value of the point on the line is given by y=mg+D.That is (g,mg+D) is the point on (2) or (1).If y-coordinate h of the given point (g,h) is such that $h > mg+D$ then $h > -Ag/B - C/B$ or $Bh > -Ag-c$ as $(B>0)$. or $Ag+Bh+C > 0$. Also $h > mg+D$ implies that the point (g,h) belongs to the upper half plane H_1 generated by the line Ax+By+C=0. As (g,h) is any arbitrary point in the plane satisfying $h > mg+D$ is equivalent to $Ag+Bh+C > 0$ therefore all points (x, y) of the plane where $y > mx +D$ satisfy $Ax +By+C > 0$.Since (g,h) belongs to H_1 the upper half plane so also all points (x,y), $y > mx +D$ lie in H_1. Hence solution set $\{ (x, y) \in R^2 / Ax +By + C > 0 \} = H_1$

Observe that all points in the upper half plane H_1 satisfy Ax+By+C >0.If (g,h) be a point in the plane with $h < mg +D$ then exactly similarly we get $Ag+Bh+C < 0$. Also as $h < mg +D$ all these points will lie below the line $y = mx +D$ .Hence all points (x, y), $y < mx +D$ will lie in the lower half plane H_2 generated by $Ax +By+C = 0$.Hence

$$\{ (x,y) \in R^2 / Ax + By + C < 0 \} = H_2$$

All points in the lower half plane H_2 satisfy Ax+By+C<0.

(ii) $m > 0$, $D \leq 0$

In this case the graph of the line $y = mx + D$------(2) or $Ax + BY + C = 0$-----(1) will look like PQ as shown below as D is negative.If D=0 then (2) will pass through the origin(0,0). (Figure 6)

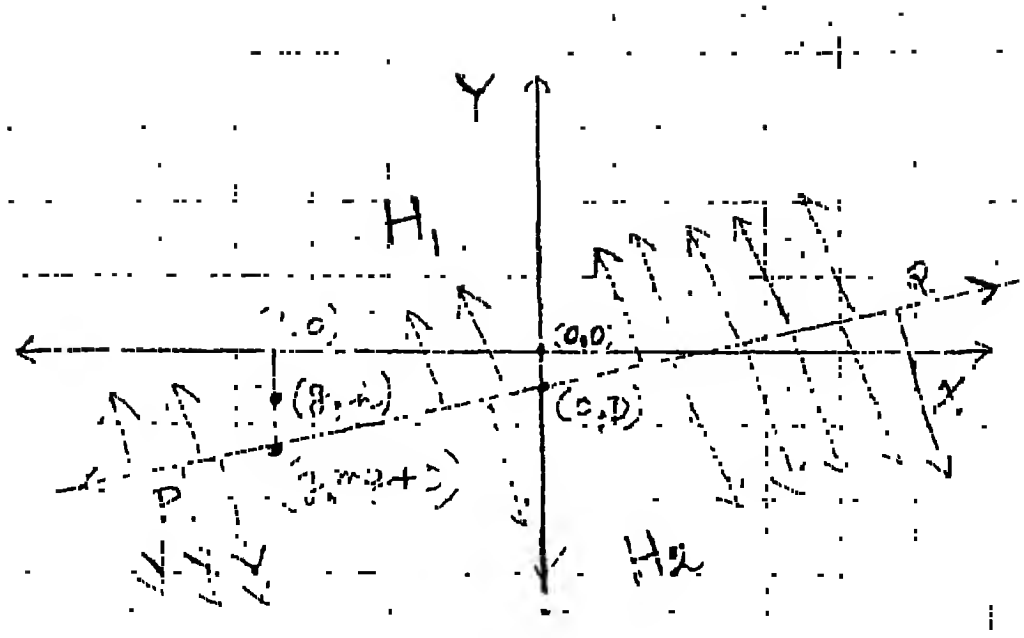


Fig 6

As in case (i) if (q,h) is a point with h>mq+D then Ag+Bh+c>0. Similarly if h < mq+D then Ag+Bh+C < 0.So as in case (i) we get H_1 and H_2.

(iii) m < 0 , D > 0

In this case the graph of the line $y = mx + D$ -----(2) or

$Ax+By+C = 0$ --------(1)

will be like the one shown in the figure below (Figure 7)

Again the line (2) divides the plane into two half planes H_1 and H_2.The upper half plane $H_1 = \{(x,y) \in R^2 / Ax+By+C \geq 0\}$

while the lower half plane $H_2 = \{(x,y) \in R^2 / Ax+By+C < 0\}$

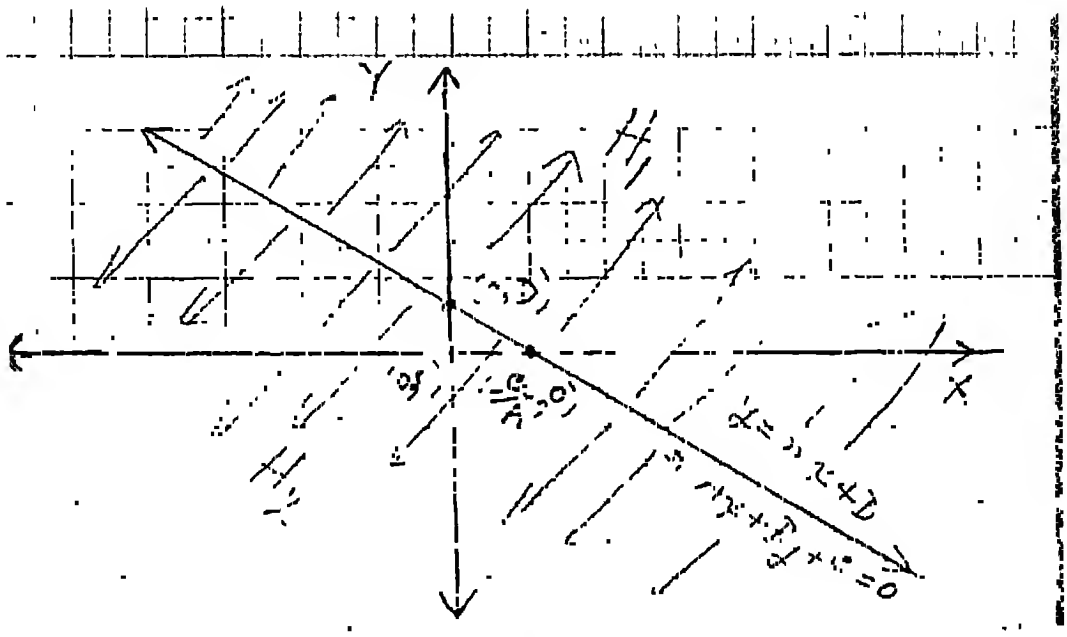


Fig 7

(iv) $m < 0$, $D \geq 0$

Exactly here also $H_1 = \{(x,y) \in R^2 / Ax+By+C>0\}$
and $H_2 = \{(x,y) \in R^2 / Ax+By+C<0\}$

Note: Of course for deciding about H_1 and H_2 we take definitely known points (x_1,y_1) in H_1 and (x_2,y_2) in H_2 after the graph of the line is drawn. We always know the points where the line (1) intersects the axes. These two points help us in identifying points (x_1,y_1) in H_1 and (x_2,y_2) in H_2. We prefer to take the point (x_1,y_1) in one of the the axes. Similarly for (x_2,y_2) in H_2. After the selection of (x_1,y_1) and (x_2,y_2) we calculate the values Ax_1+By_1+C and Ax_2+By_2+C. If $Ax_1+By_1+C > 0$ and $Ax_2+By_2+C < 0$ then all points (x,y) in the half plane H_1 containing (x_1,y_1) will satisfy $Ax+By+C>0$ and points in the other half-plane H_2 containing (x_2,y_2) will satisfy $Ax+By+C<0$.

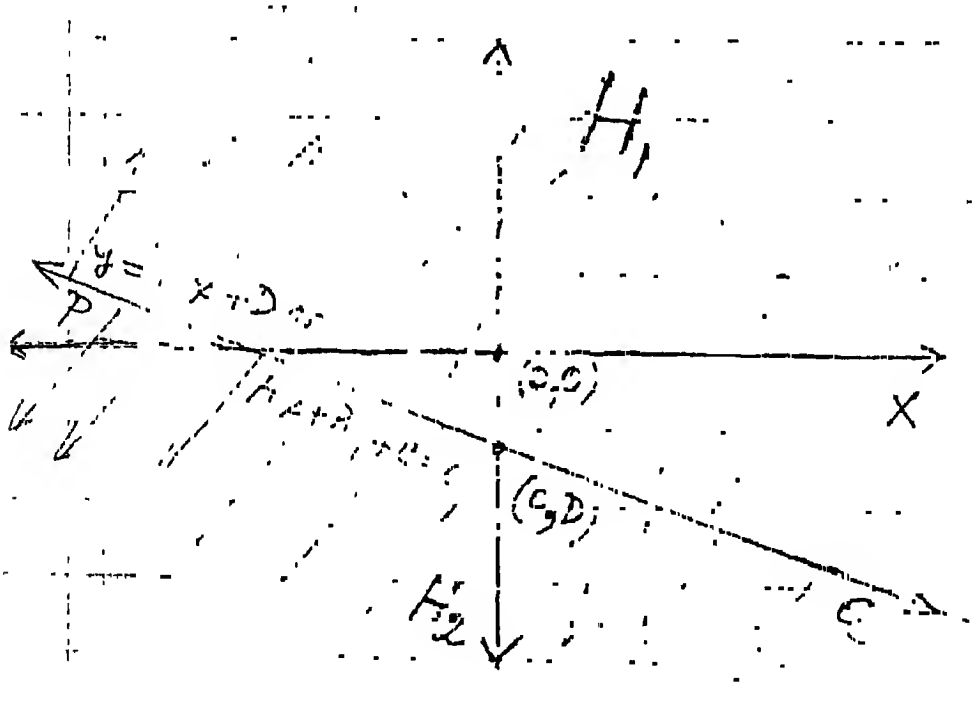


Figure 8

If the line $Ax+By+C=0$ ------(1) does not passthrough $(0,0)$ then $(0,0)$ belongs to one of the half planes. If $C>0$ then $(0,0)$ belongs to H_1, the upper half plane while if $C<0$ $(0,0)$ belongs to H_2.

Exercise : Draw a sketch of the graph

(i) $3y - x - 8 > 0$ (ii) $9x + 3Y - 7 < 0$ (iii) $3x < -5$
(iv) $6y + 5 > 0$

We solve (i) $3y - x - 8 > 0$
First we draw the line $3y - x - 8 = 0$ ....(1) or
$3y = x + 8$ or $y = x/3 + 8/3$ ....(2)

We put the values (0,0) in $3y - x - 8$ which becomes $= -8 < 0$
Thus (0,0) lie in the lower half plane
$H_2 = \{(x,y) \in R^2 / 3y - x - 8 < 0\}$ generated by line(1)
Hence upper half plane $H_1 = \{(x,y) \in R^2 / 3y - x - 8 > 0\}$

Observe that the graph of any strict inequality of first degree in (x,y) is a half plane, excluding the points on the line represented by the first degree equation.

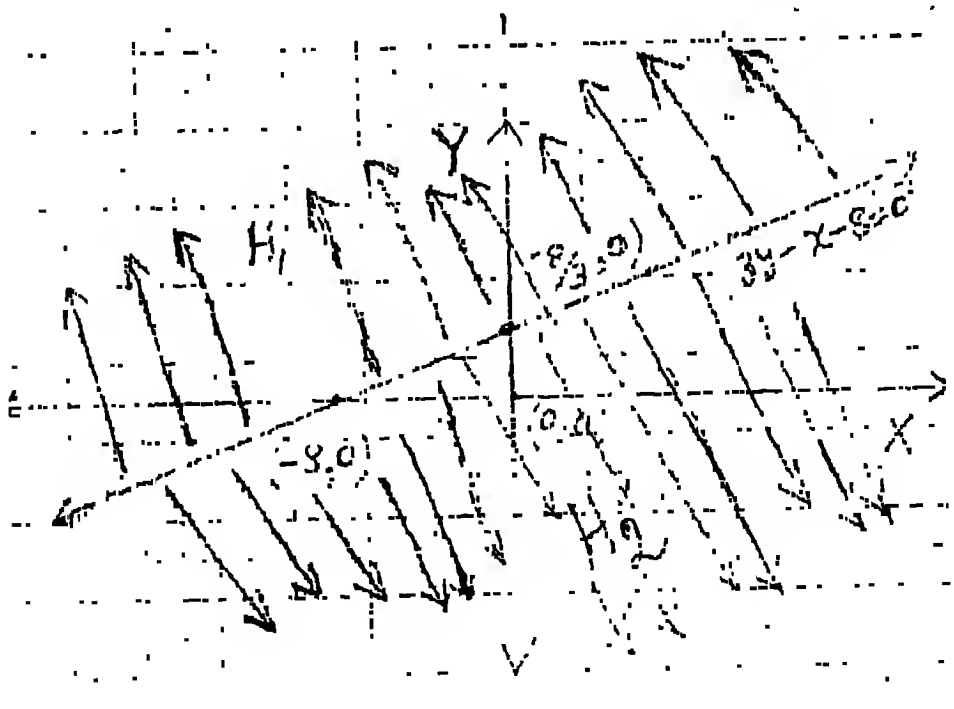


Figure 9

Exercise :Draw a sketch of the graph
(i) $3y - x - 8 \leq 0$ (ii) $5x - 2y + 6 \geq 0$
(iii) $y < 3x - 1$ (iv) $3x - 5 \geq 0$ (v) $y + 6 \leq 0$

We draw the graph of (i).Its graph will be

$H_2 \cup \{(x,y) \in R^2 / 3y-x-8=0\}$ where H_2 is obtained in the last solution.
In this case we see that the graph is the closed half plane H_2 consisting of the line $3y-x-8=0$ and half plane below it .

1.10 Solution set of two or more linear inequalities in two variables

Exercise : Draw a sketch of the graph defined by the given system of inequalities.

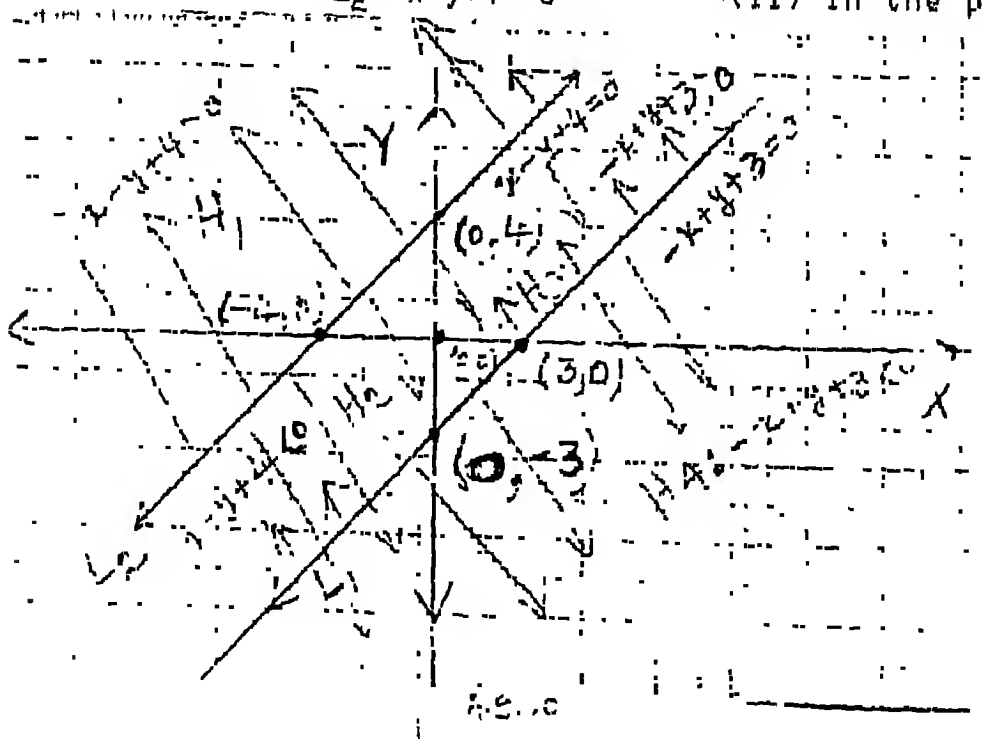
i) $2x+y \leq 4$, $y-2x \geq 4$
ii) $3+y \leq x \leq y-4$
iii) $4x + 3y-7 > 0$, $6x-y-5 < 0$

Two interesting lines divide the points of the plane into four regions.

Each of these regions is the intersection of the two half planes generated by one line with that of two half planes of the other line.Each of them ,therefore,is defined by a pair of linear inequalities.

Let us draw the graph of (ii) :
Now (ii) is equivalent to
$3+y \leq x$ and $x \leq y-4$
or $-x+y+3 \leq 0$ and $x-y+4 \leq 0$
We draw the lines

L_1: $-x+y+3=0$ ————(i)
L_2: $x-y+4=0$ ————(ii) in the plane.



The two lines (1) and (2) are parallel as (1) and (2) are equivalent to $y=x-3$ ----(1)
$y=x+4$ ----(2) and hence they never intersect.Therefore the set of points which satisfy

$-x+y+3 \leq 0$ and $x-y+4 \leq 0$ or $3+y \leq x$ and $x \leq y-4$

$y+3 \leq x \leq y-4$ or $3+y \leq x \leq y-4$

is : $H_4 \cup L_1 = H_4 \cup \{(x,y) \in R^2 / -x+y+3=0\}$
where H_4 is the lower half plane generated by the line L_1: $-x + y + 3 = 0$.

1.11) Draw a sketch of the region,if there is one,defined by the inequalities $x \geq 1$, $y \leq 0$, $2x-y-4 \leq 0$, $x+y-7 \leq 0$ and $4x + 2y - 3 \geq 0$.

From the given inequalities we derive the lines L_1, L_2, L_3, L_4, L_5.

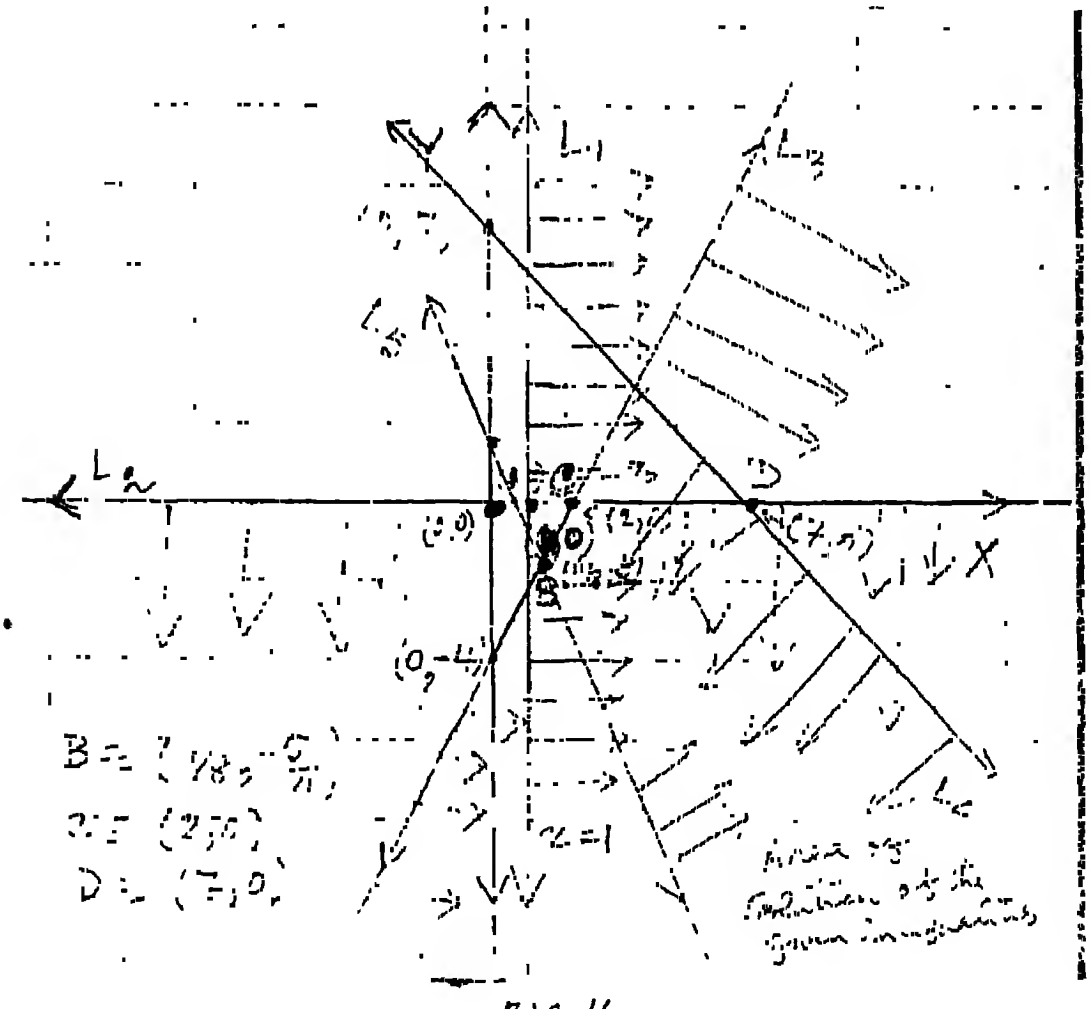


Fig. 11

given by $x=1, y=0$, $2x-y-4=0$, $x+y-7=0$ and $4x+y-3=0$ respectively.

We proceed to determine if there are any points which satisfy each of the inequalities given above.

All points to the right of the line L_1 including L_1 satisfy $x \geq 1$ .Similarly all points below the y-axis i.e L_2 including L_2 satisfy $y \leq 0$ .Again all below the line L_3 including points on L_3 satisfy $2x-y-4 \leq 0$.

Similarly all points in the lower half plane generated by L_4 including points on L_4 satisfy $x + y - 7 \leq 0$ .Lastly the upper half plane generated by L_5 including points on L_5 satisfy $4x+2y-3 \geq 0$. Let B be the point of intersection of L_3 and L_5. Then B has the coordinates (11/8,-5/4).Let C be the point of intersection of L_3 and L_2. Then C has the coordinates (2,0). Let D be the point of intersection of L_1 and L_4. Then D has the coordinates (7,0).

So all points in the fourth quadrant bounded by the halfray of L_5 starting from B(11/8,-5/4),the segment BC,C=(2,0) on the line L_3,the segment CD on the x-axis,D = (7,0) and the halfray of L_4 starting from D;the boundary points also being included,satisfy the given five inequalities.

The graph is shown in the diagram above.

Exercises (i) $6x - 2y - 7 < 0$, $4x + y - 6 > 0$

(ii) $3 + y \leq x \leq y - 4$

(iii) $x \geq 1$, $y \leq 0$, $2x - y - 4 \leq 0$

(iv) $3x - y - 4 \leq 0$, $x + y - 7 \geq 0$

(v) $x \geq 0$, $y \geq 0$, $y \leq 3$, $x + y - 5 \leq 0$, $2x + y - 8 \leq 0$.

Draw their graphs

MENDEL'S PRINCIPLES

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Mendel's Laws of Heredity

Gregor Mendel (1822-1884) is appropriately called as the "Father of Genetics". He made revolutionary contributions with his experiments on garden pea, Pisum sativum, conducted in a monastry garden and this laid the foundation for the Science of Genetics. Mendel was a modest man who graduated from High School in Brunn (Austria- now Brno in Czeckoslovakia). He entered in Augustinian monastry and was ordained priesthood in 1848. He had a great desire to become teacher. He left Brunn and studied at the University of Vienna for two years. When he returned from Vienna he again became teacher in Brunn's Modern School where he served for 14 years. He then joined the Chruch and started his experiments on garden pea in 1856 in a small garden of the monastry. After 9 years in 1865 he published his historic paper in the "Proceedings of the Brunn National Science Society". No one realised the importance of his contribution and his work remained unnoticed for 35 years. In 1900, Mendel's paper was discovered simultaneously by three botanists: Hugo de Vries in Holland, Carl Correns in Germany and Ercivon Tschermak in Austria. It was only then that his work was recognised much after his death in 1884.

Mendel was lucky to have a garden pea as plant for his hybridization experiments. In this plant, there are several varieties which exhibit qualitatively different characters. He could recognise seven such contrasting expressions of characters. These characters as investigated by Mendel are as below:

Character	Contrasting Expression
1. Form of seed	Smooth:wrinkled
2. Colour of Cotyledon	Yellow: green
3. Colour of the seed coat	Grey-brown white
4. Form of pod	Inflated:Constricted
5. Colour of unripe pod	Green:Yellow
6. Position of flowers	Axial:Terminal
7. Length of the stem	Tall(6 to 7 feet): Dwarf(9 to 18 inches)

By selecting the above seven pairs of contrasting characters Mendel was lucky that these characters neither showed any linkage, epistatic reaction or quantitative inheritance.

With his background of mathematics, Mendel was a better ~~xxxxx~~ stasticiah than a naturalist. And with his great perseverence and dilligence he could deduce his laws of inheritance from his hybridization experiments on garden pea. Pea plants are very favourable for hybridization. Self pollination in them can be easily prevented by carefully removing the anthers before they open in the bud and cross pollination is easily effected by smearing the stigma at the receptive stage with the required pollen.

MONOHYBRID CROSS:

Mendel started his experiments by taking into consideration these seven pairs of characters, one character at a time. Such cross is called as monohybrid cross. In one such experiment, Mendel raised two varieties of garden peas, tall and dwarf. When self-fertilised, tall plants always gave rise to tall while dwarf plants gave rise to dwarf plants. Mendel then crossed these two varieties. ~~xxx~~ From this cross, all the offspring in the first generation were tall - the dwarf plants have disappeared from the F1 generation.

Prior to Mendel, the general belief was that dissimilar characters, when crossed, would blend and result in intermediate character in the offspring. Mendel, however, found that there is no blending of characters in the offspring, the character of only one parent was seen in the offspring, the other character seems to have disappeared.

Mendel did not stop here. He self-fertilised the plants of the F1 generation. In the second generation, Mendel found that the character which has disappeared in the first generation reappeared in some plants of the second generation. Careful classification of the plants in the second generation showed that about 3/4 of the total plants were tall, while 1/4 were dwarf. Such 3:1 ratio always appeared in all the monohybrid crosses. Mendel designated the character that appeared in F1 as dominant and the character that reappeared in a smaller number of plants in the second generation as recessive. Thus in F2 generation, about 75% of the plants showed the dominant character. With these results Mendel speculated and arrived at the following assumptions to explain ~~x~~ his results.

1. There are definite hereditary units (Mendel called them factors, we now call them genes) which are responsible for the transmission of characterstics.

2. Each character in an organism results from the presence of two factors, one derived from each parent. This is also called as Law of Unit Character.

3. The two genes responsible for a character may be similar or dissimilar. If dissimilar, one of them will be dominant and the other recessive. If the dominant and recessive are present together, the dominant character alone will be expressed in the body of the organism and the recessive will remain masked by its dominant counterpart. The two genes that represent one character are now called as alleles. This is also called as LAW OF DOMINANCE.

4. Law of Segregation: The two alleles that remain together in the body of an organism separate and go to different gamets at the time the organism produces gamets for the purpose of sexual reproduction. So a gamete will have only one allele of a character (purity of gamets,) and never both the alleles.

Mendel devised the system of using letters as symbols for the factors (the heredity determiners). He used small letter for a recessive factor and a capital letter of the same kind for the dominant factor. Thus, he used capital "T" for tallness and "t" for dwarfness. Let us now represent the monohybrid cross by way of using symbols and see how Mendel put the result of these monohybrid (one character) crosses (Fig.1).

All the progeny of the first generation were tall plants, after following the law of dominance. Mendel went further, and self-fertilised the plants of the first generation, as shown below (Fig.2). Again following the law of dominance, Mendel found that 3/4th of the plants in the F2 generation are tall (TT & Tt), while 1/4th of the plants are dwarf(tt).

At this point we must introduce two other genetic terms which will make our discussion much easier. The tall plants are of two kinds according to the genes which they carry (TT or Tt), but only of one kind according to the expression of the genes (tall). When we refer to the type of genes we use the term "GENOTYPE" and when we refer to the expression of the genes we use the word "PHENOTYPE". Thus in the above cross the phenotype ratio is 3:1 i.e. three tall (TT,Tt) and one dwarf (tt), while the genotype ratio is 1:2:1 i.e. TT:Tt Tt:tt.

[illegible], while the [illegible]

Genotype: Genetic constitution of an organisms.

Phenotype: The physical appearance of an organism resulting from its genetic constitution or genotype.

Mendel studied all the seven pairs of alternative characterstics and all behaved and showed the similar results as were shown by tall and dwarf plants. The following table shows the results as Mendel found in various different monohybrid crosses of the seven pairs of contrasting characters.

Results of Mendel's First Experiments on Seven pairs of characteristics in garden pea

Characterstics	F2 Results		Ratio
1. Form of seed	5474 Smooth	1850 Wrinkled	2.96:1
2. Colour of Cotyledon	6022 Yellow	2001 Green	3.01:1
3. Colour of Seed Coat	705 Gray-Brown	224 White	3.15:1
4. Form of pods	882 Inflated	299 Constricted	2.95:1
6. Colour of unripe pod	428 Green	152 Yellow	2.82:1
6. Position of flowers	651 Axial	207 Terminal	3.14:1
7. Length of stem	787 Long	277 Short	2.84:1
8. All characterstic	14889 dominant	5010 Recessive	2.98:1

We may also introduce two more terms here for our bette understanding.

Homozygous: When an organism is having identical alleles at two corresponding loci (TT or tt).

Heterozygous: When a organism is having two different alleles of a single gene (Tt).

DIHYBRID CROSS:

After establishing the behaviour of monohybrid cross, Mendel directed his attention to dihybrid crosses, i.e. crosses which involve two different characters that are separately inherited. One of these crosses involves the Colour and Shape of the seeds after drying. He found that some plants produced round (smooth) seeds while others gave wrinkled seeds. A monohybrid cross has already shown that

round was dominant over wrinkled. Again some seeds turned yellow when dried while others remained green, and in this case yellow is dominant over green. When he crossed plants producing yellow round-seeds with others producing green wrinkled seeds, he obtained all yellow-round seeds in the F1 generation. He then planted these seeds and self fertilised these plants to find out the results in the F2 generation and found four distinct types of seeds were produced in the ratio of 9:3:3:1, giving rise to four different phenotypes as below:

9: Yellow and round seeds
3: Yellow and wrinkled seeds
3: Green and round seeds
1: Green and wrinkled

In all he collected 556 seeds out of which 315 were yellow and round, 101 yellow and wrinkled, 108 green and round and 32 green and wrinkled, roughly in the ratio of 9:3:3:1 as mentioned above. Out of these sixteen 9/16 show both dominant characters, 3/16 showed one dominant and one recessive, 3/16 showed other dominant and other recessive c 1/6 showed both recessive characters. Thus Mendel obtained not only the two parental combinations, but also two new combination resulting from other mixtures of the characters than those found in the two parents. This showed that two factors do not tend to stay together in the same combination in which they are found in the original parents P1. This separateness of behaviour among genes is called as the PRINCIPLE OF INDEPENDENT ASSORTMENT. According to this principle, the separation or segregation of allelic genes of gene pairs on one pair of homologous chromosomes during meiosis is entirely independent of the segregation of allel genes on other pairs of homologous chromosomes.

Using the appropriate symbols, Mendel's dihybrid ratio can be represented graphically as below (Fig.3).

Each of the F1 parents gives rise to four types of gametes. When put on the Punnet square we will get the following results.

	RY	Ry	rY	ry
RY	RYRY	RyRY	rYRY	ryRY
Ry	RYRy	RyRy	rYRy	ryRy
rY	RYrY	RyrY	rYrY	ryrY
ry	RYry	Ryry	rYry	ryry

Phenotypic Rato will be 9: 9:3:3:1
Gento typic Raio will be 1:2:2:4:1:2:1:2:1
This is explained in the following chart:

	Geno Type	Number of individuals	Pheno type	Total no. of each%
1.	RRYY	1	Round yellow	
2.	RRYy	2	-do-	
3.	RrYY	2	-do-	9
4.	RrYy	4	-do-	
5.	RRyy	1	Round Green	3
6.	Rryy	2	-do-	
7.	rrYY	1	Wrinkled Yellow	3
8.	rrYy	2	-do-	
9.	rryy	1	Wrinkled Green	1

Out of the above, the genotype RRYY and rryy will bree true on self-fertilisation, because they are homozygous fo both characters and resemble the original parents. All the other fourteen are heterozygous for one or both the charac ters and will segregate in different ratio in the next generation.

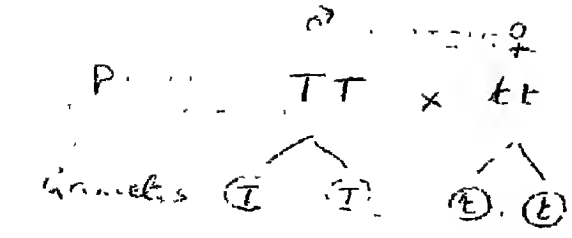

Fig. 1

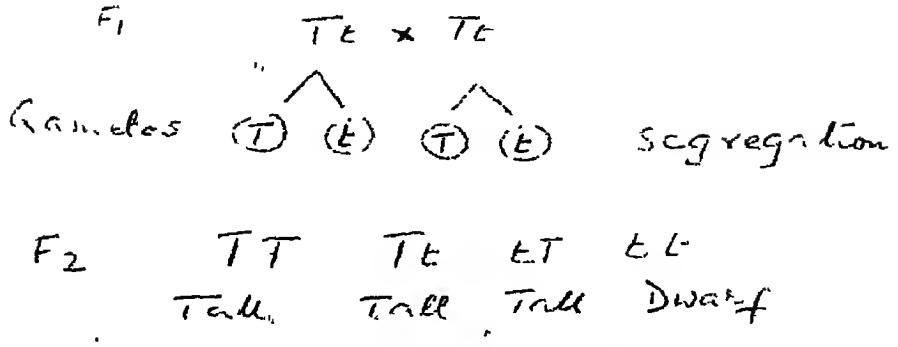

Fig. 2

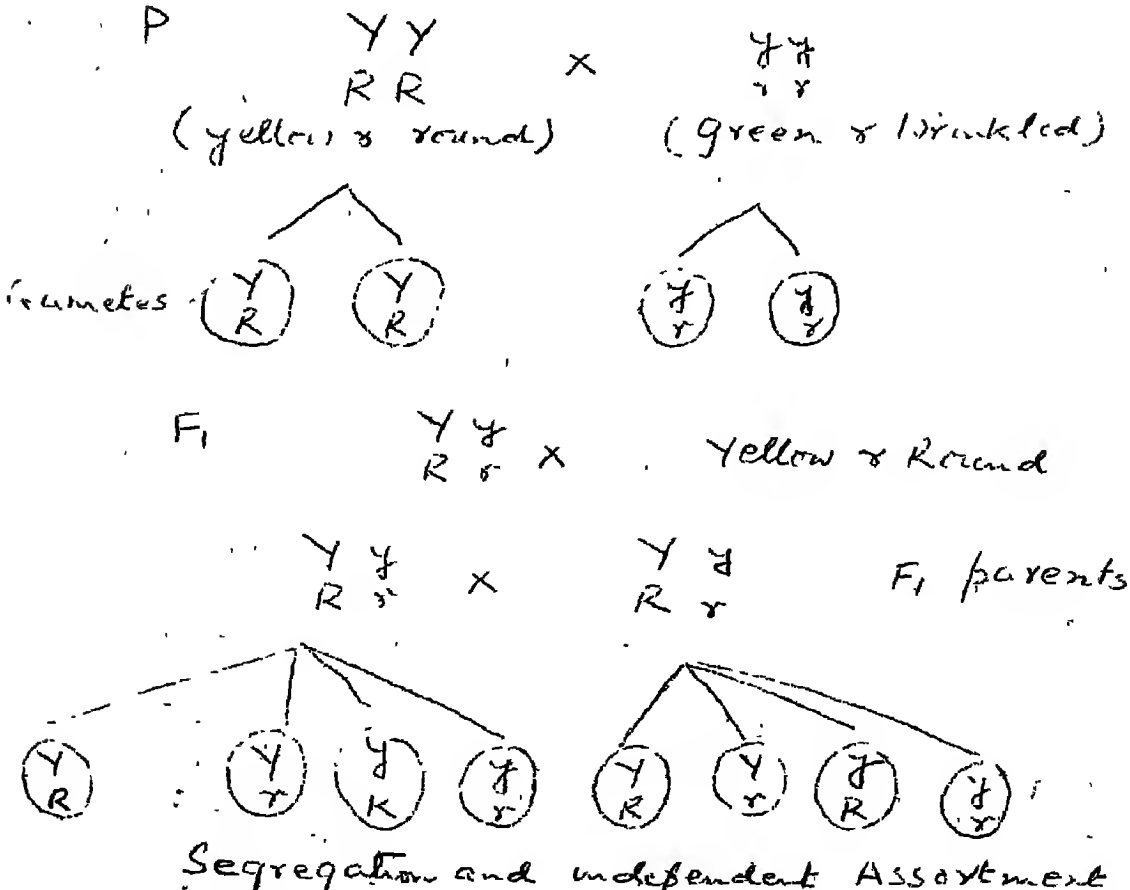

Fig. 3

SURVIVAL OF THE FITTEST

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Darwin laid most stress upon survival; individuals having favourable variations survive, while the others perish. This phenomenon has been termed "the survival of the fittest". The fittest were thought of as those individuals that possess inheritable characteristics enabling them to succeed in the struggle for existence in the particular circumstances and environment in which they find themselves. Since they are survivors, the "fittest" then become the parents of the next generation, members of which inherit the favourable characteristics from their parents.

In other words, it means that survival in itself is not the only or even the chief concern. Thereal point is not survival but contribution to the next generation. Obviously a dead animal cannot become a parent and some living animals do not become parents. So far as contribution to evolution is concerned, a living animal that does not reproduce might just as well be dead. Thus the success in struggle for existence means success in contributing to the next generation. The reproductive process is a complicated one, subject to many influences. Fertility is affected by the health and well-being of the individual and these in turn depend on a variety of physiological and even psychological factors. In the "struggle for existence" significance is therefore, placed both on characteristics that make for survival and on characteristics that make for high fertility.

A somewhat extreme example may help to emphasize the point. Imagine two competing groups A and B of animals, each group consisting atleast 1000 individuals in the beginning. Of group A, 800 individuals survive to maturity; of group B only 500 individuals survive. But in group A, the reproduction rate is such that each individual is replaced by one descendent, whereas in group B each individual is replaced by two descendents. Which is more successful group? Obviously group B is, since in the next generation it will number 1000 individuals while group A will number only 800. The most successful individuals or groups are those that contribute their genes in greatest number to the building of the next generation.

Individuals having most offspring are the fittest ones - this is what the fittest means in natural selection theory. Fittest does not mean strongest or fastest or healthiest or most intelligent, but to one which leave more offspring. Thus "Natural selection results from the cumulative action of all forces tending to ensure that individuals possessing one genetic constitution shall have larger number of offspring than the individuals possessing some other constitution". Thus if a mutation contributes in a way to the leaving of larger number of offspring it will be perpetuated in increased proportion in the next generation since it will be carried by larger numbers of offspring. On the other hand if the mutation is not favourable, it will not be perpetuated as it will permit only to be carried in a decreased number of individuals and will subsequently disappear.

We may postulate that the first ancestral horses to come from woods on to the plains were chased by predatory animals. The action of predators would constitute one of the checks upon the too rapid increase in number of these ancestral horses. In the resulting competition to survive and leave progeny, which individuals would succeed? If among the population of ancestral horses a mutation arose producing longer legs, possessors of that mutation might be able to run faster than others without mutation. Therefore, the horses not possessing the mutation would become food for predators before they had the opportunity to mate and reproduce. Thus the horses having the mutations for long legs would produce more offspring with the result that more horses of the next generation would inherit longer legs than the parental generation. If the natural selection continued in the same way for several generations the short-legged horse might disappear entirely, leaving the field to the possessors of the longer legs. If now a second mutation occurred, increasing the length of the legs more, possessors of that second mutation would be favoured in the struggle for existence with the result that some generations later all horses would have the second mutation, the possessors of the first mutation having been eliminated. And so step by step the progressive lengthening of the leg observed in the evolution of the horse might be explained through the operation of natural selection of successive mutations.

POPULATION

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Objectives: 1. To understand the definition of Population, 2. Population characteristics, 3. Environmental parameters influencing the population, and 4. The necessity of Population studies.

Men of similar nature easily get together and form a group contained in the expression, "birds of the same feath flock together". Likewide, in nature organisms of the same species form a group known as Population.

A POPULATION IS A GROUP OF XXX INDIVIDUALS OF THE SAME SPECIES, OR GROUPS WITHIN WHICH THERE IS FREE FLOW OR EXCHANGE OF GENETIC INFORMATION, OCCUPYING A GIVEN SPACE.

You know that the biological levels of organisation comprising protoplasm cells, tissues, organs, organ system individual population communities - biosphere. This is als referred to as biological spectrum. The study of last thre aspects of the spectrum constitutes ecology. A group of organisms capable of potentially interbreeding but do not interbreed with similar groups of other organisms is known as species. An assemblage of organisms of such a species is called population (e.g. Lotus plants in ponds, Litorina in rocky shore). Groups of organisms of the same species may occur in different geographical regions (e.g. vast number of Indo-pacific marine organism, high altitude flora and fauna).

Increase in numbers is achieved by reproduction, passi transport and active locomotion.

Aggregation may result from the activities of one bree ing unit (one individual) in a sexual reproduction or two individuals constituting the unit in sexual reproduction e Hydra, sponges, social insects, fish etc. Aggregation may the result of the descendants coming together of many bree ing units e.g. simultaneous release of eggs followed by the larvae within a restricted period.

Members of the s-necies may congregate as a result of the effect of currents or wind force. This is more characteristic of aquatic environment because of the regular differential water movements e.g. Planktonic organisms that are negatively phototactic and positively geotactic tend to remain in deeper circulation and are mechanically concentrated.

Vast majority of animals and certain motile algae form association by active locomotion. Animals are drawn to a particular area in response to a physical characteristic of the environment e.g. positive phototaxis drawing insects to a light source. Members may be attracted by specific reactions of their own kind. This is called mutual attraction. These members are not necessarily of the same parents. In higher organisms like fish, birds and mammals specific reactions like vision, calling notes and contact colours are responsible in keeping the animals together.

These members of any species at the population level when reach the climax and go beyond the target, competition sets in.

Competition between members of the same species is of serious kind, because they require the same kind of food and shelter. In plants, this competition is much easier to see. There is competition for the nutrients and light and when grown in crowded aggregration, retardation in growth is the outcome. In the case of sun-fish, it is observed that the initial stock weighing 76 gram each came down to 54 gram as the initial stock reproduced and there was eventually crowding. This is known as the crowding effect.

A population has its own characteristics which characterise the group rather than the individual and is a self-regulating system. The study of number of organisms and the factors responsible for their abundance and distribution constitutes population.

Desnity or the relative numbers of individuals exercise great influence on the community and on the ecosystem.

The size of a population in relation to a definite unit of space is termed population density. Density may be expressed as average or regional density with reference to a total area (i.e. crude density) or with refreence to the niche or actual area in the habitat available to the specie (ecological density). When size of the population is unifor number of individuals is taken into consideration for asses ing the density and in other cases biomass (i.e. wet weight or dry weight or carbon or nitrate content) is considered.

The size or density of the population is determined by the reproductive rate, natality, mortality, immigration, emigration, migration and abiotic environmental factors whi we study in the present chapter.

Organism follow a definite pattern in their ability to spread over k in a given area. Broadly speaking one of t following three kinds of distributional patterns is seen among organisms.

(a) Random distribution: In this case the probability of an individual occurring at any one spot in a given area is the same as the probability of its occurring at any other spot.

(b) Uniform distribution: Individuals occur in groups more regularly.

(c) Clumped distribution: Individuals occur in groups. In a given area, in respect of a population three zones of distribution can be made out. Of these the innermost is zone o normal abundance, outer to it is the zone of occassional abundance and the outermost is the zone of possible abunda

The maximum rate of production and population increase constitute biotic potential.

By processes inherent within the organism, a maximum bi rate and a minimum death rate are more or less fixed per every species. In an ecosystem many factors operate. Some harmful climatic changes and attack by diseases check the population increase. If these do not exist and the populati remains unchecked, repurcussions by way of food shortage, space problems will result. The sum total of these influenc is called environmental resistance. So, the actual rate of increase realised would be a balance struck between biotic potential and environmental resistance.

After the initial attainment of the maximum size there are three courses open to population: (a) Maintenance of the same level for a long period, (b) A decline and eventual extinction, (c) Fluctuate regularly or irregularly. In the case of (a) condition of food supply etc. must keep pace wit the population. If harmful conditions intensify the decline is irreversible and the result in extinction. On the other hand, if there is increase and reduction, it is fluctuation. The size of the population constantly fluctuates above or below the level of carrying capacity. These changes in the size of the population may be because of the changes in the physical environment or interaction within the population or both or due to interaction between closely related species These fluctuations may be seasonal or annual in nature.

A knowledge of these phenomenon has enabled to develop the concept of optimal yield i.e. how much to exploit and how A low yield occurs by over exploitation resulting in a small breeding stock. Under exploitation results in overcrowding. In terms of practical application, population size is import- for exploitation and market value. In sparse population yield for unit effort is lower.

Natality denotes the birth rate or the production of the new organisms in a population. This is expressed in two ways.

(a) Maximum or physiological natality (i.e. theoretical production of new individuals under ideal condition). However, this is never realised in nature as all females are not equally fertile and all eggs do not hatch and all larvae, see and seedlings do not develop into adults.

(b) Ecological or realised density i.e. increase of a population under given set of environmental conditions.

Death or mortality refers to the rate at which individual are lost by death, mortality varies with age of the organisms.

Age distribution: In a population, individuals of differe ages exhibit a certain proportion or ratio to each other. For all practical purposes a population may be divided into three age groups, viz., prereproductive, reproductive and post reproductive. The proportion of age groups in a population determines the current reproductive status of a population and from which the future of the population may be predicted.

Large number proportion of young individuals characterise a rapidly increasing population and an even distribution of all age groups denoting a stable population while large numbers of old individuals indicate a declining population.

Population growth rate or growth form is the net result of natality, mortality and dispersion from the group.

If we are to understand the ecology of a species, we have to study and measure these attributes of the populati Some populations tend to be self limited by inherent mecha- nism, the rate of growth decreasing as population increase thus being clearly density dependent. Some populations may overshoot their energy and habitat resources unless checke by external factors. These populations grow in geometric sequence until problems of food and space become actute. I certain populations, the reproductive rate is greater at intermediate densities than at higher or lower densities.

Members of a population commonly restrict their activi- ties to a definite area, called the home range. Some even develop territorial instincts.

Home range of an organism provides it basic necessitie of life (food, cover, resting place). Territorial instinct means that a group of individuals holding a particular are will not tolerate others of the same species. A variety of mammals (man, deer, mice), lizards, fishes and certain ins exhibit teritoriality.

Organisms exhibit a variety of movements (often exten travel) in search of favourable feeding and breeding sites

Birds manifests the phenomenon of migration which is the seasonal movement to and from breeding places. Migrati is also exhibited by fishes. When species move out impell climatic factors or search of food, the phenomenon is call emigration. In this case individuals move upto long place never to return e.g. Locusts. When organisms roam about irregularly due to over-population that is called Nomadis

In short population are influenced by many varied fac but an underlying orderliness is equally evident. The fol ing seem to be established factors.

1. All animals have an innate ability to reproduce and multiply under favourable conditions.

2. Favourability for a given species is whether its population is permitted to grow or decrease.

3. Every animal born must die once. So, the population cannot remain for a long period unless the birth rate and death rates are virtually equal. If the number of births and deaths are apparently different, a population would increase or decrease geometrically.

4. As population grow they use up more space and more food. Increasing density intensifies the action of inimical factors i.e. increase in the number of natural enemies or increase in the accumulation of harmful wastes or metabolites.

5. As animals produce such effects on the environment, grouping populations reduce the favourability or some factors whereas decrease in population, permit favourability to recover. Such compensatory reactions govern population to maintain levels related to the properties of animal in question and those of the environment.

6. Consequently when operating in association with density governing factors, nonreactive factors such as climate may have influence over density because most reactive factors influence either the properties of an animal or its environment.

7. Operating by themselves non-reactive factors cannot determine population densities. For, if sufficiently favourable, they permit indefinite multiplication, if not they cause the population to dwindle and become extinct. On the other hand, they limit distribution to those areas within which they are favourable. The most important density stabilising factors are:

   i) Competition
   ii) Fecundity
   iii) Survival of young
   iv) Predation
   v) Emigration
   vi) Disease and physiological stress.

The necessity for population studies need not be over emphasised in view of the fact that the entire planning and development projects of human welfare hangs upon them only. After all natural resources are not inexhaustible and as such a critical and radical appraisal of the populations of different edible and useful organisms is prerequisite and mandatory.

ECOBIOLOGICAL EQUILIBRIUM & ECOBIOLOGICAL CRISIS

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There has been an increase in awareness and recognition of the intimate reciprocal relationships among plants, animals and their abiotic environment. Plants and animals are well adapted to the local environmental conditions and the physical and chemical factors of the habitat. The environmental parameters determine the size and compositions and function of the biologic communities. The physical environment causes fluctuation in density, course of development, and reproductive periodicity of different species since the biotic communities hinge upon the physical environment. There is a parallelism between the fluctuations in the community and the biotope. The natural communities are not rigid structures; But, these changes are subjected to a certain degree of control and they fluctuate about an equilibrium level. Hence the communities are under constant fluctuating dynamic equilibirium. The communities and the individuals together with their environment constitute the so called ecosystems. The ecosystems may be as big as the Ocean or as tiny as the puddle left by a rain storm. The ecosystems are apparently independent systems comparable to a manned space-ship. Light sustains the life and provides energy to it analogous to the solar cells in a space-ship providing electricity. The heterotrophic animals incapable of transforming sunlight metabolically into usuble energy rely upon the autotrophic green plants which use the light energy, water, carbon dioxide and nutrients to produce organic matter. Certain of the heterotrophs are carnivores. Thus, the solar energy trapped by the plants circulates through the entire ecosystem in the form of organic matter. The organic matter is subjected to the activity of the decomposers and is converted into the basic components - water, CO_2, and minerals. This is how the very complicated cyclic process takes place in which man is a key component.

Ecocatastrophies are known to occur whenever there are violent changes in the abiotic factors. However, when the conditions are favourable, the populations and communities return to their original equilibrium as their environment returns to its previous stage.

Temperature and food supply are the important factors regulating the animal populations. Long spells of cold in winter

are known to reduce stocks of piscivorous birds, since the ice covering the waters prevents the birds from finding food. Similarly, population density of a species fluctuates with the differences in the availability of food. Over-population and over-grazing also are known to cause deficit food supply.

There is certain amount of self-regulation on the part of the populations, controlling their densities. For example, the tadpoles of tree toads, grass frogs, fire-bellied toads, British toad, etc. are known to eat their own spawn and that of other species sharing their habitat. As such, this behaviour prevents the over-population and is compensated by the reproductive prodigality.

There are innumerable examples of prey-predator relationships which act to bring in the biological equilibrium. The predator and the prey species are in a perpetual state of dynamic equilibrium with one another. If the prey population should become abundant, the population density of the predator rises until the number of prey have been reduced to a certain minimum. The large predator populations create food shortages for themselves and thereby causing self-decline. Eg. the lemmings committing mass suicide after the density reaches a certain maximum and the food resources diminished.

The above account demonstrates how under natural circumstances the biological systems are maintained in a state of equilibrium.

Eversince man started exerting his influence upon nature, many natural habitats have vanished and many have been reduced. The atomic age witnessed the impoverishment of the Tundras, Sea islands, etc.

In the hunt for wealth from the soil, the exploitation of the natural terrestrial systems started. The arms race between the nation and nuclear weapons are threatening the self-regulatory abilities of the natural systems. Human made land-scapes constitute the artificial or pseudoecosystems with very limited capacities of self-regulation.

The Neolithic agriculture and animal husbandry turned the nomads into settlers, but the human influence was less. The rapid growth of populations and technology brought about great many changes leading to total destruction of natural surroundings and restriction of human life linkages with nature. Any mistaken tampering with the complex machinary of nature

brings in a magnified revenge. The repair of the damage can't be undertaken with the existing ecological ignorance.

When a man lived by gathering wild plants, he was in a natural equilibrium with plant-eating insects. But with the onset of monocultural agricultural practices, the insects turned out to be pests destroying entire harvests. As agriculture advanced and extended, the pest insects also extended with it, into regions where they had never lived before. Eg. Potato beetle of the South Western U.S.A. rapidly spreaded as far as South-eastern Europe.

The introduction of chemicals as a means of preventing outbreaks of pests, in the age of industry, though paid initial dividends, caused new problems. Insects became resistant to insecticides (EgDDT); new pest spcies spearheaded destruction of crops in the face of their natural predators annihilation. Pesticides found their way into the bodies of warm blooded animals, including man himself and impaired their health. The natural equilibrium is no longer maintained since the artificial monoculture systems are incapable of self-regulation.

To maintain equilibrium and check the pest populations, it is necessary to resort to judicious biological methods . E.g. Prey-Predator systems, Host-parasite system. But failure are common and in some cases unsuspected affects may be seen upon the native animals. E.g: To controle the plague of rats in the sugar cane plantations of Jamaica, the mangoose (Herpestes edwardsi)was introduced there in the second half of the last century. No doubt, the mangoose controlled the rats in a short time, but became so dominant , that it in turn became a pest, attacking domestic animals and exterminating many native island species of amphibians, snakes, lizards, birds and small mammals. Attempts to maintain ecological balance in monocultures by purely bioligical or chemical means have been frustrated time and again. The only wayout to manipulate the nature is to adopt methods based on ecological principles. An integrated approach to agriculture i.e. a synthesis of chemical and biological pest control, new methods of crop rotation, artificial fertilization, cultivation and breeding programmes based on the recent researches should be able to restore the ecological balance that is lost. This method may bring in agrarian regions more nearer to the natural habitats. However, this kind of programmes hinge upon the maintenance of water balance. In the absence of which the consequences for the ecosystem are prone to be disasterous.

The thought less felled of the forest reduce the retention of water in the concern regions. In the past for grazing purposes clearcut land areas are demarcated but the result was not only the destruction of the plant cover but also the packing of the soil was enhanced by the trampling animals. With the result the water storage capacity of the soil was decreased and eventually culminated in errosion, leaching and periodic floods, Subsequent attempts to restore a normal biological and hydrological system by reforestation were found to be quite ineffective. Likewise modification of the water courses with aintention to prevent the floods may also proved to be disasterous. Biodiversity gets diminished with the deteoriation of water balance resulting from cannalisation and land drainage. Pollution is the other menance effecting the quality of water, Densly populated centres of industry, raw-sewage and industrial waste made the aquatic plant and animal communities to shrink and collapse. The self purging (purification) capacity of the water bodies is overstrained by the pollution. With the result instead of a balanced relationship between producer, consumer and decomposers, the scale has been tipped toward decomposer (bactria and other micro-organisms). The higher levels of biological oxygen demand and chemical oxygen demands impaired the biodiversities of the aquatic communities. Entrophication leading to the anoxic conditions would result in the collapse of the whole intricted trophic system of the water body. Treatment of sewage and other waste carrying water appear to be the only remedy for restoring the ecobiologically equilibrium "only an understanding of biological interaction can help man to correct past errors and to prevent by careful planning further disruption of the biological equlibrium". (W. Tobias)

MILK MICROBIOLOGY

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Milk is the most nutritive food for all mamals. It is a complete food where all the necessary components of food are available. Due to this it is easily contaminated by micro-organisms of all types. The contamination is either at the time of milking or during transport.

Study of Microorganisms: There are three methods by which the micro-organisms (specially bacteria) as milk may be studied.

I. Qualitative estimation of bacteria in milk:

Milk, after it leaves the cow and becomes exposed and mixed with air, aquires an oxidation reduction potential(O/R) of about +300 mu . Asbacteria grow in the milk, they consume oxygen and produce reducing substances that eventually lower the O/R potential to a negative value. The rate of shift in O/R potential depends on the number and kind of bacteria and the rate of their metabolism. This shift can be followed by adding an appropriate indicator to the sample of the milk. This indicator is usually methylene blue.

Procedure: Take 10 c.c. of the milk sample (samples) in a test tude. If the samples are to be compared take equal quantity of milk (10 c.c.) in different ordinary test tubes. Put methylene blue solution by touching the apex of a needle. Start recordin time. The sample which decolourises methylene blue earliest will be having maximum number of bacteria.

Standard plate count: This is known as the standard method in its minute details. This is also called as Petri-plate method.

Procedure: (a) Collect the milk sample in a sterilised test tube (b) plug it with cotton (c) take one c.c. of this sample and dilute in 100 ml of sterilised water (d) pore the agar media in petri-dishes (d) allow it to cool down but should not solidify (f) pour 1 ml of the dilute milk sample (g) mix the milk throughly keeping the petridishes closed and on the table surface or inoculation chamber surface (h) store them (i) study them after 48 hours onward.

III. Director microscopic count: As the milk smear is directly made on the slide and the micro organisms are studied. This is known as direct microscopic count.

Procedure: (a) Make a mark on the slide with a glass marking pencil an area of 1.0 sq.cm. (b) Put .01 ml of milk sample in the middle of the marked area (c) Spread it with a sterilised needle within the entire area (d) dry it without disturbing the area (e) stain it, study them, and count their number (f) After counting their number a quantitative calculation may be made.

Calculations: The area on the microscopic field is calculated with a stage micrometer applying the formula πr^2. Here 'r' is radius of the focussed area (microscopic field). The number of the microscopic field will $\frac{100}{\pi r^2}$ sq.mm. Let us say this number is 'n' or $\frac{100}{\pi r^2}$= 'n'. This is known as number of micfoscopic field. From our counting we can know the number of bacteria in our microscopic field. So the number of bacteria in 'n' number of microscopic field can be known. But, since this represents only .01 ml of milk sample for 1.0 ml this is further multiplied by 100. This can also be said the number of bacteria percent in 1.0 ml of milk sample is $\frac{100 \times 100}{\pi r^2} \times n$. Here the average number of counts is to be taken. This method is easy, simple and gives immediate result. In spite of its merit it is not popular because it is not accurate and many confusing stained materials are seen. The

bacteria present in milk is knwon as lactobacteria. Other micro-organisms also may be present in the sample.

Soil Microbiology

Soil is a very reach place for microbial flora. Its non-living components are mineral particles, organic residue, water and gases. Higher form of life are root system of higher plants, many animal forms (rodents, insects, worms etc.) and a large number of microbes. The microbes may be bacteria fungi, algae, protozoa and viruses. The diversity of the microbial flora presents a problem in any attempt to enumerate the total microbial population of a soil sample. Therefore different cultural methods are applied for studying different microbes. Here an attempt is made to study the fungal flora by dilution petri-plate method.

Procedure: (a) Take a sterilised hard glass test tube and a clean knife (scalpel); keep some plugging cotton (b) collect soil from two inches below the surface of the site with the knife (scalpel). Plug it and bring it to laboratory. (c) weigh 0.1 gram of the soil after through mixing (d) make a suspension in 10 c.c. of sterilised distilled water (e) take one c.c. from here and dilute it in 10 c.c. of sterilised water. This is 100 time diluted suspension of the soil (f) Sterlise five pairs of petridishes, pour nearly 5 c.c. of P.D.A. (Potato dexbose Agar) media in each pair inside the incubation chamber (g) while the media is liquid but not hot put one c.c. of soil suspension in each of the petri-plate, rotate each one slowly but immediately in '8' figure manner touching the surface of the inoculation chamber or on the table and side (known as inoculation). Repeat it ten times in order to spread the suspension and along the media (b) keep at normal temperature in the culture chamber (i) start studying the colonics and fungal flora from 48 hr. ohward.

Note: For confirmation the experiment is to be repeated.

Preparation of Media for Microbial culture

1. Medium: Material on, or in which micro-organisms are grown in the laboratory is called medium.

2. Culture: Cultivation of micro-organisms in group. This group may be of homogenous or heterogenous organisms.

3. Pure culture: When the cultivation is only of homogenous group or all similar or only one kind of organism it is called pure culture.

4. Requirements: For the preparation of 1000 c.c. of P.D.A. media (potato dextrose agar media).

(A) Chemicals:

i) 20 gms of Agar.
ii) 20 gms. of Dextrose (Sugar)

(B) Natural food source: 50 gms of potato.

(c) Glasswares

i) Petri dishes in pairs
ii) Conical flasks 500 c.c.(two)
iii) Conimal flask 1000 c.c. (one)
iv) Beaker 500 c.c. (Two)
v) Glass rods 10-20cm(two)

(D) Instruments and other materials:

i) Non absorbant cotton 1 packet of 100gm.
ii) Presure cooker of 10 litre capacity
iii) Gas burner or electrical heater
iv) Source of water

5. (i) Weigh 50 gms of potato. Clean it but do not peal.

(ii) Cut into small pieces (1-2 cm). Put it in a beaker add 200 c,c. of water. Heat it slowly for about 1/2 hrs or till it starts forming water turbid, Filter the whole material through a piece of cloth and take the decant in 1000 c.c. conical flask.

(iii) Dissolve 20 gms. of Agar in a beaker. Agar may not dissolve at room temperature. Boil the solution taking ~~was~~ water not more than 100 c.c.

(iv) Dissolve Dextrose (Sugar) in another 100 c.c. of water.

(v) Put the agar and dextrose solution with decant of boiled potato in a 1000 c.c. flask. Add more water to make it 1000 c.c.

(vi) Plug the flask with cotton tightly. Put oil paper around its neck and tie with threads.

(vii) Sterilise the petridishes (wrap petri pairs) in paper tie them, keep in wire basket and sterilise for 1/2 hrs. at pressure in the pressure cooker). Pour 5 c.c. of media in each petridish only in the inoculation chamber.

NOTE: If inoculation is done immediately, put the inoculated petridishes in culture chamber after marking them with glass marking pencil. Resterilise the un-used medium.

Pre-caution: Put sufficient water in the pressure cooker, after sterilisation open the cooker carefully when it becomes cool.

Staining Bacteria:

Bacteria can be stained with Methylene blue solution (Single stain) but more elaborate system of stain is used known as gram stain. Gram stains are used to distinguish between gram positive and gram negative bacteria.

Procedure: Make a smear of bacteria on a slide. Dry it up. Flood it with methylene bluc for one minute(Single stain), wash it slowly under the tap water. Mount it with glycerine and see under the microscope(high power).

For gram stain the smear is first flooded with crystal violet solution. Wash it with tap water slowly. Stain with iodine solution, wash it with alcohol. Put saffranin for a minute. Wash it slowly under tap water. Mount it in the glycerine and see under high power of magnification.

Here some bacteria take crystal violet colour and are not decolourised after washing with alcohol. They are gran positive bacteria. Some bacteria are stained pink or red with saffranin because their crystal violet colour has been washed with alcohol. They are gram negative bacteria.

Staining of Fungi:

Fungi generally form overlaping colonies. They may be of different colours and sizes. Study them carefully.

Procedure: Take a bit of fungus with a clean needle on a clean slide. Put a drop of lacto-phenol cotton blue stain on it. After one minute transfer the material on another clean slide. Put a drop of glycerine, mount it and see under the low magnification first and then under high power.

CONCEPTS OF ENVIRONMENTAL POLLUTION

Dr.D.G.Rao
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Used in broad sense, the term "Pollution" refers to any change in the natural quality of the environment brought about by chemical, physical or biological factors.

In 1965, the U.S. President's Science Advisory Committee Environmental Pollution Panel, restoring the quality of the Environment gave "Pollution is the unfavourable alteration of our surrounds wholly or largely as by-product of man's action through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution and abundance of organisms. These changes may affect man directly or through his supplies of water and of agricultural and other biological products, his physical objects or possessions or his opportunities for recreation and appreciation of nature.

Pollutants are numerous gases (such as sulphur dioxide and nitrogen oxides) and particulate matter (such as smoke particles, lead aerosols and asbestos), in the atmosphere, pesticides and radioactive isotopes in atmosphere and in water-ways; sewage, organic chemicals and phosphates in water, solid wastes on land, excessive heating (thermal pollution) of rivers and lakes and many others. Pollution nearly always refers to the consequences of human activity clearly most drugs and food additives together with those industrial poisons which present purely occupational hazards. Some pollutants cause particular concern because they are described as poisons. Even such non-poisonous substances as glucose and common salt can be injurious or lethal when they are present in sufficiently higher concentrations in living organisms. By the same token, familiar poisons such as carbon monoxide and arsenious oxide are apparently harmless at relatively low concentrations. In practice, poisonous pollutants in the living environment are usually present at levels well those of known to have harmful effects.

The affulent societies of the developed nations of the world are likely to be more concerned about the unfavourable effects than those nations in which poverty and hunger are major unsolved problems. The unfavourable effects of pesticides and fertilisers run off are likely to be of less concern in a country in which insufficient food production

is leading to malnourishment and starvation or in which insect-born diseases are major contributors to human morbibity and mortality than in a country in which agricultural surpluses, relatively pure water supplies and strong public health programme.

Poverty, starvation and pollution all reflect mankind's failure to design social and political institutions capable of properly assessing and controlling technological innovations. Serious problems of poverty and hunger exist in the United States despite the progress of the last several decades and the progress that has been made has been accompanied by the aggravation of many existing environmental problems and the production of new ones.

Level and movement of pollutants.
Natural and man-generated pollution.
Almost completely man-generated.
Chlorinated hydrocarbons (DDT etc.), Lead aerosols.
Substantially man-made.
Oil in the ocean.
Phosphates in running waters.
Substantial contributions from natural sources.
Hydrocarbons in the atmosphere and Radiation.
Sulphur oxides in the atmosphere.

CONCENTRATION OF POLLUTANTS:

Concentrations of pollutants are often emphasised by fractions.

1 ppm corresponds to one part pollutant per one million parts of the gas, liquids or solids mixture in which the pollutants occur.

In the case of gas mixtures, the reference is generally to ppm by volume, whereas in the case of liquids and solids the reference is generally to ppm by weight. In recent years it has become customary to express gaseous pollutant and particulate matter in the atmosphere in mass density units of micrograms per cubic metre.

FRACTIONAL CONCENTRATIONS

Symbol	Definition	Fraction
ppm	Parts per million	10^{-6}
pphm	Parts per hundred million	10^{-8}
ppb	Parts per billion	10^{-9}
ppt	Parts per trillion	10^{-12}

At first glance, a concentration of 1 ppm seems ridiculously small and negligible. Nevertheless concentration of pollutants at levels of 1 ppm or less can have serious adverse effect.

1 ppm of phenol in water is lethal to some species of fish.

0.2 ppm average SO_2 level in the atmosphere has been shown to lead to an increased human mortality rate.

0.02 ppm peroxybenzyle nitrate in smog can cause severe eye irritation in humans.

LONG DISTANCE MOVEMENT OF POLLUTANTS

There is accumulating evidence that many types of pollutants can become distributed over the whole earth in relatively short period of time.

Radioactive fallout - throughout the world form atmospheric nuclear tests within few days.

Worldwide distribution of DDT and its metabolites: These were first developed for pesticidal use in the late 1930 and released for civilian use in 1945; since that time they have been widely used throughout the world, they are now widely distributed throughout the marine ecosystem of the pacific ocean, for example probably having been transported by air. Levels of DDT and its metabolite of over 100 ppb have been found in the liver and fat of animals that never leave the Antartic ice peck, such as Adelie penguins.

Persistance: Some pollutants remain dangerous indefinitely. Berylium and Lead being examples. Others that are eventually broken down into hamless compounds may still persist in the environment for long periods of time. The time needed for the pesticide level to be reduced to less than 25% of the original level applied, estimated

5 years for chloro dane
4 years for DDT
3 years for Dieldrin
1.5 years for Piclorам
5 months for 2,4,5-T and
1 month for 2,4-D

It has been estimated that inorganic mercury compounds in bottom sediments of lakes and rivers may take 10 to 100 years to be converted into methyl mercury, an organic form, dangerous to animal life. Radioactive nuclei decay exponentially with a wide range of half-life, the half-life being the time necessary for half of the original number of nuclei to decay.

Isotope	Half-Life
Be^{7}	53 days
Kr^{85}	10.7 years
Sr^{90}	28.9 years
I^{131}	8.1 days
Cs^{137}	30.2 years
Ra^{226}	1,602 years
Pu^{239}	24,400 years

BIOLOGICAL CONCENTRATION:

Another important characteristics of pollutants is that they may be concentrated biologically so that levels in one part of an ecosystem are much larger than those in other parts. This typically occurs in food chains; levels in an organisms are higher that those in the food. Hickey et al, 1986 studied lake Michigan ecosystem and found DDT levels of

0.014 ppm (wet weight) in mud sediments on the bottom
0.41 ppm in bottom feeding crustacea.
3 to 6 ppm in various fish (alewives, chub).
Over 2400 ppm in the body fat of a fish eating gulls.

One reason for this sort of concentration is that chlorinated hydrocarbons are much more soluble in fat than in water.

Through the food chain is the exceptionally high level of Cs^{137} found in human living for north of Europe, North America, particularly Lappa and Eskimos.

In this instance, Cs^{137} from fallout was concentrated in Lichens, then in Reindeer and Caribou feeding on the lichens, and finally in human eating those animals, body budens of Cs^{137} were 10 to 100 times greater than those occurring in human at more temperate latitudes.

SYNERGISM AND ANTAGONISM: It is impossible to discuss the effect of pollution probably nearly be discussing the effect of individual pollution. In many cases, the combined effect of two or more pollutants are more severe or even qualitatively different from the individual effects of the separate pollutants - a phenomenon known as Synergism.

Wide spread injury to Peanut crops in Texas in 1966 and 1967 were identified due to synergistic action of ozone and SO_2.

Numerous studies have shown that some types of particulate matter, such as aerosols of soluble salts of ferrous ions, manganese and venadium can increase the toxicity of SO_2. Such an increase in toxicity usually referred to as potentiation.

Sometimes the combined effect of two pollutants are less rather than more severe and this refers to as antagonism, e.g. cyanides in industrial wastes are quite poisonous to aquatic life, and in the presence of zinc and cadmium, they are extremely poisonous (a synergistic effect), apparently due to the formation of complexes, in the presence of nickel, however a nickel cyanide i.e. not very toxic is formed (an antagonistic effect). The occurrence of synergistic effects makes it difficult to study the effect of pollution since so many pollutants are present in the environment.

Mineral Cycles in Ecosystem

Compiled by
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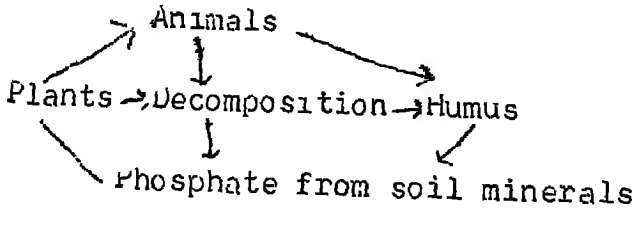
Reader in Botany

Minerals are essential for Ecosystem Functioning:

Apart from solar radiation, there are about 22 elements needed to build organic substances by living organisms especially plants. Some of these are needed in large quantities like C,H,O,N, P etc. and are known as Macronutrients. Some of these are readily available in nature in large quantities as C,O,N. Several elements though needed in extremely small quantities (Micro-nutrients) are scarcely available in nature(Co, Zn, Boron,Manganese etc.) Majority of these nutrients are made available by series of cyclic arrangements in nature. The cyclic movements of the nutrients in the ecosystem constitute yet another important aspect of Ecosystem interrelationships and are referred to as Bio-geo-chemical cycles: They are categorised in

1) Hydrological cycle or water cycle involves the exchange of water between oceans, land masses and as a result of evapo-transpiration and atmosphere as a result of precipitation. The balance between evapo-transpiration and precipitation in a given region determines its fauna and flora.

2) Sedimentary cycles are exemplified by cycles like phosphorus and sulphur. A simplified diagram of phosphorus cycle is shown as follow:



As a constituent of protoplasm (nucleic Acid, phospholipids and numerous phosphorylated compounds), Phosphorus is one of nutrients of major importance to biological systems but of all the nutrients phosphorus perhaps, is the most rare nutrients available only through the decomposition of phosphate rocks and humus.

Gaseous cycles are exemplified by carbon, nitrogen and oxygen cycles. All these have the atmosphere as the major reservior. These cycles show little or no permanent change in the distribution and abundance of the elements.

Nitrogen cycle involves the conversion of atmospheric N_2 into nitrites and nitrates (nitrification) by nitrite and nitrite bacteria). Ammonia (Ammonification) by Ammonifying bacteria and conversion of Ammonia, Nitrates and Nitrites into gaseous N_2 (Denitrification) by denitrifying Bacterial. Several types of plants especially members of pea family (Leguminosae) directly convert atmospheric N_2 into nitrogen compounds (subsequently incorporated with protoplasm) with the help of symbiotic bacteria like Rhizobium (recollect root modules of Pea) - a process known as Nitrogen fixation. Blue green algae are important in this regard. What appear to be a simple cycle is in fact more extensive, complicated and ordered. It is also highly specific in that certain organisms are able to act only in certain phases of the cycle.

Carbon Cycle is perhaps the simplest of all nutrient cycles and is essentially perfect cycle in that carbon is returned to the environment about as fast as it is removed. This basic movement of carbon, is from the atmospheric reservoir to producers to consumers and from both these groups to decomposers and thence back to reservoir. It should, however be mentioned that Oceans hold more than 50 times greater CO_2 than the atmosphere and there is a constant exchange of CO_2 from atmosphere to the oceanic reservior. In past few decades increased use and incomplete combustion of fossil fuels has resulted in detectable increase of atmospheric carbon. Prediction is for a 25% increase in atmospheric CO_2 by the end of century. What the long term effects will be of such an increase or of further increase is a matter of considerable and immediate concern which needs to be discussed in detail.

In the natural undisturbed state these cycles will continue to operate continuously so that sufficiency of the materials they circulate is ensured.

Dynamics of Biosphere

Compiled by
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A living organism is the manifestation of several living functions, and each such function begins with raw materials. All raw materials ultimately come from the physical environment of the earth. Environment in literal sense means "surrounding" but in terms of biology 'environment' is a very complex terms and includes three "spheres" of the non-living world viz, Lithosphere, Hydrosphere and Atmosphere. Lithosphere means the minerals, rocks etc. Hydrosphere means water and its various forms and Atmosphere includes different types of gases that envelop the earth. It is in this type of complex physical environment that all living organism live and get modified. Living organisms constitute the biotic component of the earth and include plants, animals and microbes. It should be noted that the biotic components exist only when there is close interaction between them and the non-biotic (Abiotic) environment and there exists a close reciprocal relationship between the two implying thereby that biotic components are modified by Abiotic components and vice-versa. Thus a highly integrated and interdependant system is formed between living and non-living organisms and this system is referred to as "Ecosystem". Take for example a small pond in your neighbourhood. It is complete ecosystem since both biotic (plants, animals and microbes) and Abiotic components(Lake mud, water, dissolved gases) exist in the system. Similarly we have forest ecosystem, grassland ecosystem, desert ecosystem as well as lakes, streams, pools, rivers, ocean etc. Even a home made aquarium kept only for decaration purposes is a complete ecosystem and it will continue to be s as long as small game fishes swim in waters enclosed within the four glass walls of the aquarium.

Let us pause for a moment and visualize how big can an ecosystem be. Ecosystem can be as small as a small pond or an aquarium too as big as ocean or the huge forests on the Himalayan tract. All the ecosystem (Aquatic and terrestrial) put together constitute yet another sphere called as Biosphere which will be discussed a little later. Suffice to say that the entire surface of the earth wherever life exists is the "Biosphere".

Biosphere and Balance in Nature

It is an established fact that there exists a reciprocal relationship among plants, animals, microbes and their non-living environment. Wherever plants and animals are found, they are of types specially adapted to the conditions prevailing around them (Habitat). The physical and chemical factors in any habitat are responsible for the size and composition of the communities (group of organisms) typically living there. Such a type of interdependence of the communities on its immediate environment produces fluctuations in number of organisms(density), course of development and reproduction time of the different species. Thus it is clear that natural communities are not rigid structures and undergo changes which, however, are not uncontrolled and continuous but are subject to a degree of control and under ordinary circumstances they fluctuate about an equilibrium level. Such types of natural communities and their environment are called ecosystems. Thus a forest which is a community of trees is an ecosystem called as Forest Ecosystem. Here collection of trees grows in the environment of its own which is quite different from the environment experienced in say a pasture land. A well developed forest may show certain changes in response to fluctuations in environmental conditions like light, winds, ppt etc. but such changes do not continue indefinitely and reach to a stage of stability. The same holds true for a grassland which represents another type of ecosystem called 'grassland ecosystem. Similarly we

have smaller ecosystems like ponds, lakes, pools and also ecosystems of enormous sizes like oceans, deserts, Tundra land and of course, forests and grasslands. Whatever be the size of ecosystems, ultimately all of them depend upon one environmental factor. i.e. light from which comes the energy that supports the life.

As explained elsewhere, the light energy is used by green plants in photosynthesis - a process in which water and Co_2 are converted into organic matter. Animals are incapable of transforming sunlight metabolically into usable energy and so must rely upon their food, either eating the plants directly (Herbivory) or using the more indirect approach of the carnivores. Thus the solar energy taken up by the plants circulates through the entire ecosystem in the form of organic matter. Finally, it reaches the "decomposers" - a special group of microscopic organisms that feed upon dead plants and animals.and in doing so reconvert them to their original components - water, carbon dioxide and mineral salts. In this very complicated cyclic process man, too, has his place and will be explained later. Under natural conditions, these processes approach an equilibrated state. When the factors controlling an ecological system suddenly depart from their ordinary ranges (range --- Maximum ---- Minimum), this balance can be serously upset and in extreme cases a collapse of the system may result but such circumstances under natural conditions are very rare.

Amongst the various factors that control the equilibrated state of ecosystem, climatic factors especially temperature are decisive in regulating the plant and animal population. For example, prolonged cold periods can indirectly reduce the stock of fish eating birds since the ice covering the water prevents them from finding low. Each harsh winter may bring about sharp reduction in the numbers of any population but in mild winters the deficit is quickly made up and the populatio is once again stabilized.

Similar fluctuations in the population density of a species can be caused by differences in the availability of food. Consider a case of a deer population in an ecosystem. Due to excessive hunting of the natural predators of deer like wolves etc. make the population of wolves extinct and increase in the density of deer. At first the increase will be slow, but then, because of adequate quantities of food available and freedom from prediation, the rate accelerates till the population of deer is several times im number than in the beginning. This overpopulation consequently leads to severe overgrazing which in turn will lead to food shortage and starvation of many young deer. After some time this marked reduction in the numbers of deer results in renewal of the range land and eventually an equilibrium is established between the size of deer population and that of the food supply. Similarly overgrowth of land by plants soon results in the nutritional depletion of soil, since more raw materials are withdrawn from the soil. This depletion eventually leads to a starvation of the plants and decrease in their numbers. But the bodies of dead plants now enrich the soil again and the fewer plants which still live make less total demand on the raw materials once more present in the soil. These living plants therefore can become well nourished. Hence they may reproduce rapidly and thus circumstances increases their numbers again and the cycle is repeated.

Some biotic population can also regulate their densities autonomously, uninfluenced by environmental factors. To illustrate this point let us take an example of the tadpoles of tree toads, grass frogs etc. The tadpoles eat both the spawn of their own species and that of the other species sharing their habitat. This behaviour prevents the overpopulation that would otherwise develop as the adults lay many thousands eggs at a time.

There are countless cases of predator-prey relationships in the animal kingdom and host-parasite relationship in plant kingdom. These relathonships act to balance biological conditions. The predatory species and plant parasites(several types of fungi, Bacteria) are in state of dynamic equilibrium with the prey species and host species respectively. If the prey or host should become particularly abundant, the population density of the predator or parasite rises until the number of prey/host plants has been reduced to certain minimum. The large predator/parasite population creates food shortage for itself and must in turn decline allowing the prey/host plants to multiply again. Other biological interactions that balance the organisms in nature with respect to the number include
a) Symbiosis or the mutual association between two organisms, b) mutualism - an association of two organisms in which associated partners derive some benefit, c) Commensalism-an association of two organism in which only one partner benefits, d) competition - i.e. struggle for food space and shelter etc.

The above cited examples illustrate the kinds of factors which tend, under natural circumstances to equilibrate biological systems.

As a general rule, although the numbers of all kinds of organisms would undergo short term fluctuations, the total quantities could remain relatively constant over the long term. Biological equilibrium is 100% dependant on the balance in biological components of the ecosystem. All individuals, population and communities depend directly on abiological (Abiotic) systems or physical environment, their evolution is oriented by it and their continued existence is made possible by it. Any imbalance, discontinuity or interuption in the vital links will have direct impact on the living component of the system. Thus, nutrients, water and gases in the ecosystem tend to be used and re-used or cycled. Cycles are also referred to as Biogeo-chemical cycles.

which essentially are of two types a) gaseous cycles(like Co_2, O_2, N_2 cycles) and b) sedimentary cycles (like Potassium, Magnesium, Calcium and Phosphorus).- Unlike the gaseous cycles, the sedimentary cycles are essentially one-way flows. Elements are released from the rocks on the land by weathering or in sediments, are carried to the sea where geological processes return them to storage in lihtosphere(Earth). Since these elements don't form gaseous compounds at normal temperatures and pressures, they can't return to atmosphere and then to land except by birds or fish caught for food or by wind borne sea salts scattered over land masses. Thus these lements tend to be in short supply. In short we may say that environment is forever changing. The physical world is subjected unceasingly to various changes which alter every component of the earth sooner or later, very rapidly in some cases solwly in others. Living world is also subjected to these changes. Such changes, being produced primarily by Sun and planetory motion, occur in rhythmic, patterned cycles. Daily and seasonal climatic cycles are familiar examples.

The physical environment is the ultimate source which supplies organisms all required organic nutrients. From some of these, the required organic nutrients or food are manufactured and distributed within the living world itself. Thus all the organisms build up their bodies at the ultimate expense of inorganic materials withdrawn directly from physical environment. Organic wastes produced by the living organisms return t. the enviroment. Also, to the environment are returned the dead bodies of organisms. Organic wastes and the dead bodies are subjected to decay caused by special group of organisms called the saprotrophs (Bacteria, fungi). Result of decay is the retransformation of the returned substances into the same kind of inorganic material which were withdrawn from the environment originally (Fig.). Living organisms may therefore be visualised as a transient construction built out of materials

borrowed temporarily from the environment. The earth conserves all its raw materials on a long term basis and this makes possible an indefinitely continued, repeated recreation of living matter. Therefore, the continuity of life depends on the parallel continuity of death. Life and death of the organism contribute in major ways to the movement of earth substances in cycles. Billions of tons of materials are withdrawn from the envrionment into billions of organisms all over the world and after use in various forms are finally put back into the environment as they were obtained. This is how in nature biological components live in perfect harmony with nonbiological components but Man, though an intrisic part of same ecosystem in the biosphere considers as part from it, as such his interaction with natural systems modifies the environment to suit his own purposes (Shelter, food raising, road buildings etc.). Due to increasing influence of man upon nature, many natural habitats have vanished and many more have been reduced. Even the polar regions and the tundra, the sea islands and the deserts are beginning to loose much of their virgin quality. In the search for wealth from the soil, modern technologies open them up for exploitations. In most of the rest of the world, wherever nature has managed to survive in some form, the origin habitats have given way to landscapes marked by man and capable of only a limited amount of self regulation. As a nomad human influence on nature was small. The growth of the earth's population and the onset of the age of technology brought about vast changes amounting to total destruction of natural surroundings in parts of the world. Almost any mistake man makes in tampering with the complex machinary of nature brings a magnified revenge, many of the early attempt to repair the damage have failed because of Ecological ignorance. Today people are gradually coming to realize that nature can't be so readily manipulated, and that the only way out of the dilemma

is to adopt methods based on fundamental ecological principles. An integrated approach to agriculture - a synthesis of chemical and biological pest control, new methods of crop rotation, artificial fertilisation and cultivation and breeding programmes based on recent research - should eventually succeed in restoring the lost ecological balance and bring the agrarian regions more nearly into line with natural habitats. Only an understanding of biological interaction can help man to correct past errors and to prevent, by careful planning, further disruption of the biological equilibrium.

STUDY OF MITOSIS IN ROOT TIPS OF ONION

Compiled by Dr.P.K. Durani,
Reader in Botany

I. Obtaining root tips:

Grow onion/garlic on wet sand for 3-5 days depending on the temperature. A number of new roots will emerge by this time.

II. Fixation:

A. Cut all the newly formed roots about 1 cm in length (including tips) between 11 am and 3 pm.

B. Fix in acetic acid; 70% alcohol (1.3) overnight. The material may be stored in this fluid for months.

III. Preparation of temporary squash:

A. Requirement:

a. Acetocarmine
b. N/ 10 HCl.
c. Ferric acetate
d. Slides and cover slips
e. Needle (slightly rusted ones are better) & scalpel.
f. Spirit lamp
g. Blotting paper.

B. Procedure:

a. Take a clean watch glass. Add one drop of HCl and 9 drops of acetocarmine, and a small crystal of ferric acetate. (In absence of ferric acetate mix well with a rusted needle).

b. Place a root tip in the mixture.

c. Warm by passing over flame for a few minutes (Note: Do not heat too much. Touch your slide to the back of your hand: It should feel just warm).

d. Cut the stained root tips with scalpel to retain the deeply stained tips only. Discard the rest. Tease the tip with the needle to separate the tissues.

e. Cover with coverslip avoiding bubbles.

f. Press evenly with your thumb.

g. Pass slide over the flame and tap gently keeping the slide between the fingers.

h. Repeat the process a number of times till the chromosomes in the dividing cells have taken deep stain. CAUTION: The coverslip should not be displaced while tapping as all the isolated cells will roll and spoil the material).

i. Observe under low power and locate cell in division.

j. Observe and draw the various stages.

k. Keep from drying by waxing the edges of the coverslip.

IV. To Prepare permanent slides from temporary squash:

A. Requirements:

a. Tertiary butyl alcohol

b. DPX

c. Needle

d. Forceps

e. Petridish

f. Cover slip and slide

g. Pieces of glass rod.

B. Procedure:

a. Remove all wax from slides after stain has matured.

b. Place two small pieces of glass rods in a petridish, and invert slide over it, with cover slip downwards.

c. Fill petridish with tertiary butyl alcohol, and leave undisturbed till cover slip drops off.

d. Carefully remove slide, add a drop of DPX and cover with <u>new coverslip</u>.

e. Keep aside till perfectly dry.

f. Remove coverslip very carefully with forceps and place it on a <u>new slide</u> with drop of DPX; Dry in oven at 40^{c} C.

STUDY OF MEIOSIS IN ANTHERS

AIM : To study the meiotic stages in pollen mother cell.

<u>REQUIREMENTS</u>

Anhydrous ethyl alcohol - 500 ml.

Glacial acetic acid - 250 ml

Chloroform - 100 ml.

Needle

Cover slip and slides.

Acetocarmine stain

Spirit lamp

Paraffin wax

Tertiary Butyl alcohol - 250 ml.

Canada balsm.

Blotting paper.

PROCEDURE:

1. COLLECTION: Collect young buds or anthers of the desired plant preferably in the morning hours between 6.00 -8.00 a.m. (Several collections at different intervals of time will be required to find out peak period for cell division). This time varies from species to species. Repeated trials will ultimately determine the optimum time for collection).

2. KILLING, FIXING AND PRESENTATION

Fresh anthers are not available at all times and it is often necessary to make extensive collection in the field for subsequent study. Kill and fix entire bud, anthers or even large portions of an inflorescence in Farmers's or Carnoy's fluid.

A. Farmers's Fluid

Anhydrous Ethyl Alcohol	..... 75 ml
Glacial Acetic Acid	..... 25 ml

B. Carnoy's Fluid

Anhydrous Ethyl Alcohol	..... 60 ml
Glacial Acetic Acid	..... 10 ml
Chloroform	..... 30 ml

The fluids given above produce an acid fixation image, preserving particularly well the chromosomes, nucleoli and the spindle mechanism. Cytoplasm is rendered in fibrillar or alveolar form. This type of image is preferred for most studies of plant structure.

Fluids with alcohol: glacial acetic acid ratios of 2:1, 1:1 have also been used and can be tested until the optimum fixation is obtained for a given species or stage. Plant materials can be stored in these fluids for months at 0°C. However the material can be transferred to 70% alcohol after 1-2 days of fixation and stored in refrigerator for many months.

C. Smearing:

(i) Dissect out young anthers from the bud with the help of a needle and collect these at the centre of dry clean glass slide.

(ii) In case the anthers are large, chop these into small fragments with needle or razor blade.

(iii) Cover the anthers with a drop of acetocarmine and with the blunt end of needle crush the material to release the mass of sporocytes which floats in the dye.

(iv) Remove all the unusual walls of the anther with the tip of the needle.

(v) Lower a cover glass over the drop of dye and press it gently between the folds of blotting paper.

(vi) Make preliminary observation of the material under microscope. If desired stages of cell division are seen proceed further to improve

the staining. Repeat the process with fresh bud till required size of the anther is obtained.

(vii) Pass the slide quickly over an alcohol lamp flame several times.

(viii) The amount of heating must be determined by trial but not heat to boilling point.

(ix) Tap the material gently with finger tips keeping the slide between the folds of blotting paper. Don't tap too vigorously.

(x) Seal the edges of cover slip with paraffin wax, after proper stain and adequate separation of chromosomes has been achieved.

D. MAKING THE SLIDES PERMANENT

1. Carefully remove the wax along the eges of the coverslip with sharp razor blade.

2. Immerse the slide in equal volumes of acetic acid and alcohol in an inverted condition.

3. Pass the slide and the cover slip through the following fluids at 2-5 minute interval.

   a) equal volumes of ethyl alcohol and tertiary butyal alcohol.

   b) tertiary butyl alcohol changes.

4. Place the slide with smear upward on blotting place a drop of thin balsam and lower the cover glass carefully.

E. PRECAUTIONS: 1. Avoid overheating of the material.

2. Avoid excessive tapping as it damages the cells.

3. Keep the stains and fixed material stored in refrigerator till further use.

FUNCTION OF THE EYE

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Reader in Zoology.

1. The Mechanics of Vision. The eye is a mechanism in which the receptors (rods and cones) are stimulated by light energy, as a result of which nerve impulses are initiated which pass to the visual area of the cerebral cortex, where they give rise to the sensation of sight. Visual sensations are of three types: light, color, and form. Although light is the principal stimulus for light sensations, an electric shock, or a blow, or even gentle pressure can cause a visual sensation. Such a sensation takes the form of a circle or flash of light ("seeing stars"), which may occur even in the dark or with the eyes closed. These sensations are called phosphenes

LIGHT VISSION. Light has two meanings. Subjectively light refers to the sensation resulting from stimulation of the optic nerve endings; objectively, light or light energy consists of radiations which are capable of stimulating the optic nerve endings. Light rays vary in length. They travel at a speed of 186,000 miles per second. The rays that stimulate visual receptors and give rise to visual sensations range in wave length from 5000 to 7800 angstrom units: these are the radiations that produce the visible spectrum. Light rays of greater length (infrared rays) or lesser length (ultraviolet rays) constitute "black light"; that is, they do not give rise to visual sensations because receptors are not stimulated by them.

When light rays of the proper wave length enter the eye and strike the retina, they induce chemical changes in the rods and cones which initiate nerve impulses. These impulses are carried by the optic nerve to the cerebral cortex, where they give rise to the sensation of sight. The specific visual receptors are the rods and cones. Exactly how light rays stimulate them is not known. Numerous theories have been advanced, but none has been generally accepted. One that is rather widely held is the duplicate theory of vision, which maintains that the rods and the cones have distinet functions, the former functioning in dim light, the latter in bright light.

LIGHT AND DARK ADAPTATION. When one passes from a bright lighted room to dark or dim room, it is impossible to distinguish objects for a time. Slowly the contents of

the room begin to come into view and objects begin to take form. This process, by which the eyes have become adapted to vision in dimmer light, is called dark adaptation. The change is due to (a) regeneration of visual purple in the rods, which increases their sensitivity to light rays of lower intinsity; and (b) dilatation of the pupil, which permits more light to enter the eye and strike the peripheral regions of the retina, where the rods pre dominate.

After the eyes have become dark-adapted, if the same person passes to a brightly lighted area, the new light has a dazzling effect and, for a short period, vision is poor. After a few seconds, however, the eyes become adapted. This process is called light adaptation. The change is the result of (a) bleaching of visual purple, reducing the sensitivity of the rods: and (b) contraction of the pupil and partial closure of the eyclids, thereby reducing the amount of light entering the eye.

These two adaptive processes, according to the duplicate theory of vision, relate to the specialized functions of the rods and the cones. Dark adaptation makes scotopia or twilight vision passible. Li·ht adaptation makes photopia or daylight vision possible.

Scotopia. Vision in dim light is the function of the rods, which have a low threshold of excitation: that is, they respond to light of low intensity. The rods are not concerned with color vision, their visual impulses being recorded in black or white or a combination of the two, namely, gray. The rods function in dim light and darkness, when color and detail are not discernible. In the rods is a reddish pigment, rhodopsin or visual purple. , which, when exposed to light, becomes bleached. This condition is essential for stimulation of the rods. In the dark, the pigment is resynthesized. Rhodopsin is a protein linked to a pigment of the carotene group (vitamin A). Indeed, in the absence of vitamin A. rhodopsin cannot be formed and night blindness (inability to see in a dim light) results. Night blindness may also occur as a consequence of congenital lack of visual purple.

Photopia. Vision in bright light is the function of the cones, which have a high threshold of excitation: That is, light of high intensity is needed to elicit a response from them. They are operative in color vision and in the registering of the fine details of objects. When the eyes are

directed toward an object, the retinal image falls upon the fovea centralis, a small, depressed area in the center of the maculalutea. At this pint the retina is very thin and devoid of rods. This is the area of most acute vision. Surrounding the rod-free fovea, the retina contains both rods and cones, but the cones decrease progressively in number toward the periphery, where rods alone are present.

REFRACTION OF LIGHT. When light travels through a uniform medium, all the waves move at the same rate and in a straight line. How-ever, should light rays pass from one medium to another (as from air to water), their velocity is altered and the rays are bent or refracted. When the light rays pass to a medium of greater density, they are bent toward a plane perpendicular to the surface of the two media. When they pass to one of lesser density, they are bent away from this perpendicular plane. The measurement of the ability of a substance to bend a ray of light is referred to as its refractive index. This index is a relative measurement air is the basis for it, the refractive index of air being assumed to be 1.0. That of water is 1.33. Light rays, on entering the eye, must pass through the cornea, aqueous humor, lens, and vitreous body, to strike the retina. Accordingly, these are refractive media. All of them, with the exception of the lens, have the same refractive index as water; that of the lens is 1.44. The formation of an image on the retina depends on the proper functioning of these refractive media.

INVERSION OF THE IMAGE. Owing to the refractive power of the lens, light rays passing through it cross each other and as a consequence appear on the retina in a reversed position. The result is an inverted image.

PROJECTION. When an image is formed on the retina, impulses are initiated which pass to the visual centers of the brain, where they are registered in consciousness as sight. Visual sensations, therefore, occur within the brain. But the brain immediately projects these sensations out of the body to the sighted objects, which reflect the light rays that have stimulated the retina. In the process of projection (a mental process), the retinal immages are reinverted. This causes the object to appear as it actually is, that is, right side up.

ACCOMMODATION. To be seen clearly, an object must form a sharply focused image on the retina of each eye simultaneously. The process which enables one to see objects clearly at different distances is accommodation. It is dependent primarily on the elastic properties of the crystalline lens. When the eye is focused on a distant object, the surfaces of the lenses are least convex and their refractive power is at a minimum: this is far vision. When the eyes view an object nearer than about twenty feet, the lens surfaces become more convex and the refractive power of the lenses is at a maximum; this is near vision, in which the light rays enter the pupil and are brought into a sharp focus on the retina.

Mechanism of Accommodation. The crystalline lens is held in a state of tension by the pull of the suspensory ligament. Fibers of this ligament extend radially from the margin of the lens to the ciliary processes, to which they are attached. The ciliary processes are projections of the ciliary body, a part of the chorbid coat of the eyeball. Intraocular pressure causes a pull to be exerted by the suspensory ligament, which reduces the curvature of the lens. This is the state of the lens when the eyes are at rest (that is, closed, or focused on objects twenty feet or more distant). In far vision, the light rays that enter the pupil of the eye are nearly parallel and are brought to a focus on the retina. In near vision, accommodation is necessary to bring about clear vision, which is accomplished by contraction of the ciliary muscle. The fibers of this muscle are so arranged that, when they contract, the ciliary body is pulled slightly forward, and this forward movement lessens the tension on the suspensory ligament, whereupon the lens, by virtue of its elasticity, becomes more spherical. This increases the convexity of the central portion of the anterior surface of the lens, increasing its refractive power and enabling light rays from objects to be brought to a focus on the retina.

Limits of Accommodation. There are limits within which the eye can accommodate. If an object is brought toward the eyes, at a certain point the image will begin to be indistinct or blurred. The shortest distance from the eyes at which an object can be seen clearly is called the near -

point of vision. For the average young adult, this averages about 10 inches; in infants it is much less (2 to 4 inches); in old people, it is much greater becasue the lens gradually loses its elasticity (and consequently its power to accommodate) with advancing age. After the age of 50 years, most individuals are unable to accommodate for near vision. This condition, called presbyopia, can be corrected by wearing glasses with convex curvature for close work. The farthest distance from the eyes at which an object can be seen clearly is called the far point of vision. This point is infinity, that is, any distance beyond 20 feet.

Near vision requires not only a change in the shape of the lens but also two other correlated adjustments. These are: (a) convergence of the eyeballs, by which the retinal images fall on identical or corresponding points to bring about single vision: and (b) constriction of the pupil, which permits light rays to pass through only the central portion of the crystalline lens, wherein lies the greatest refractive power.

Control of Accommodation. The ciliary muscle is composed of smooth muscle fibers innervated by fibers of the autonomic nervous system. Accordingly, accommodation is an involuntary reflex activity. The stimulus that initiates the reflex seems to be the contraction of the internal rectus muscles, which brings about the convergence that occurs in near vision. Voluntary control of the extrinsic muscles thereby automatically brings about coordinated activity of the ciliary muscles. The internal recti are innervated by the third cranial (oculomotor) nerve. Postganglionic fibers supplying the ciliary musclers arise in the ciliary ganglion, which lies just behind the eye.

COLOR VISION. Colors have no objective existence; they exist only in our consciousness as subjective phenomena. What corresponds to "color sensations" in our environment are electromagnetic waves of various wave lengths. When light waves of various wave lengths strike the retina they give rise to nervous impulses which, upon reaching the brain, are interpreted as colors.

White Light. " White light" is a combination of . colored lights- red, orange, yellow, greeen blue, and violet. These constitute the spectrum produced when white light is passed through a glass prism. The spectrum is essentially a scale of color wave lengths; each colour and each shade or gradation of a color, has a specific wave length. Futher more, by mixing two or more colours new color sensations are produced White light, like many other colors, can be produced from three colors, red, green, and blue. These are called the primary colors. Any two colourswhich, when combined produce the sensation of white are called complementary colors(for example, red and greenish-blue).

Cones and Light. When the image of a well-lighted object falls or the fovea or the part of the retina immediately surrounding it, all the spectral colors of the light emitted by the object can be distinguished . The cones in this area are especially adapted for responding to light of all wave lengths. In areas a short distance from the fovea, yellows and blues can be distinguished, but not reds and greens. In the extreme peripheral regions of the retina color sensations are not elicited but only light and shades. Color discrimination is correlated to the distribution of the cones in the retina, the cones being most numerous in the fovea, absent in the peripheral regions.

Color Blindness. Color blindness is the inability to distinguish between colours.The condition may exist in a mild degree (color weakness) or it may be complete(achromatism). The latter state, in which the retina is totally insensitive to colour is very rare and is believed to be due to absence of cones. Dichromatic color vision is the condition in which the subject is blind to red or green. A color-blind individual may be unaware of his visual defect until tested and informed of the result. One of the simplest of the tests devised to detect color-blindness is the yarn test, in which the subject is required to match yarns on the basis of their colours.

Colour blindness is eight times more common in males than in females. It is inherited and sex-linked. Its mode of tr nsmission is similar to that of haemophilia.

AFTER-IMAGES. The sensation of light persists for a time much beyond the period during which the stimulus is

applied. If, for example, one looks at a bright light for a moment and then closes the eyes or turns them toward a dark surface, the sensation of light will continue for a noticeable period, then gradually fade away. By the same token, if one looks at a bright-colored object and then looks at a dark surface, an image of the object in the same color will persist. Upon this phenomenon is based the postulate that visual sensations are continuous, although visual stimuli may be intermittent. It is the principle underlying the technic of motion pictures, which consist of still pictures projected with sufficient rapidity (16 per second) for the after image of each picture to persist until the next picture is seen, with the resulting illusion of a continuous picture.

The length of time required for a light stimulus to evoke a sensation is extremely short. A light flash of adequate intensity can be distinguished, though it may persist for only 1/8,000,000 of a second. Positive after-images last only a fraction of a second.

If one looks at a colored object for a few seconds and then directs his eyes to a sheet of white paper, the image of the object will appear on the paper, but in the color that is complementary to the first, that is to say if the object is yellow, the after-image will be seen in blue. This is called a negative after-image. Should the object be black, the negative after-image will be white (and vice versa).

When one looks at a green object for a protracted time and then at a red object, the color of the latter will be intensified: This phenomenon is called successive contrast.

Visual Acuity. The degree of sharpness or distinctness of vision is called visual acuity. It is measured either by (a) the smallness of an object, that can be seen clearly at a standard distance, or (b) the greatest distance at which a standard-sized object can be seen clearly. A common type of test for visual acuity is that based on a prepared chart of test letters (Snellen test). The degree of acuity is indicated by fractions such as 20/20, 20/10, 20/40, which express the subject's visual acuity as compared with that of a normal individual. A normal eye is one by which block letters of an established size can be distinguished clearly at a distance of twenty feet.

Another, and in some respects more satisfactory, test of visual acuity is that in which the Jensen grids are used. The test involves the reading of a chart having grids appearing at different angles. This test is employed for individuals who have not learned to read and hence do not know the names of the letters. It also overcomes the objection that letters may differ in their legibility.

Visual acuity is greatest in the fovea, where only cones are present and where they are most concentrated. It decreases gradually toward the periphery of the retina. For an object to be seen in three dimensions, three separate receptors must be stimulated: a line may be seen when only two receptors are stimulated. The smallest discernible image on the fovea has a diameter of 0.004 mm.(4 microns). Images on the peripheral portions of the retina must be larger than this in order to be discerned.

Visual acuity varies greatly among individuals. The reason for this is not known, but it is suspected that differences in the structure of the retina and the susceptibility of the refractory media to disorder are the primary factors.

VISUAL FIELDS. That part of the outside world which is seen by one eye constitutes the visual field of the eye. In man, the visual fields of the two eyes overlap, with the result that most objects within the field of vision are seen by both eyes. This is termed binocular vision. The movements of the eyes are controlled reflexly and in such a manner that both eyes are directed toward the same object; there is, then, an image of the object formed in each eye. The places where these two images of a given object lie are called the corresponding points of the two retinas.

The term " visual field" is also used to describe the surface of the retina which is stimulated by light rays coming from the external visual field. The diagnosis of certain diseases of the retina and the optic pathways can be made by an analysis of changes that have occured in the visual fields. This can be mapped with the aid of an instrument called a perimeter. The area of the visual field of each eye is reduced somewhat by the eyebrow, nose, and cheek, which prevent some light rays from entering the eye.

BINOCULAR OR STEREOSCOPIC VISION. The ability to judge distance or to recognize that an object has depth is due largely to binocular vision, which results in formation of two retinal images which are slightly dissimilar owing to the fact that the two eyes view the object from different angles. The two images give rise to impulses which in the brain are fused into a single composite image. The judgment of distance depends on the degree of convergence of the eyeballs; the nearer the object, the greater the degree of convergence.

Factors other than binocular vision are of importance in the estimation of depth or distance. They are:

1. The size of the image on the visual field. The nearer the object, the larger the image formed on the retina.

2. The relative distinctness of detail. In near objects, color, form, and fine details are apparent: in distant objects, these tend to become lessdistinct.

3. Perspective. Objects that are in straight lines extending away from the viewer (for example, railroad tracks) appear to come together in the distance. This effect is employed in subjective judgment of distance. In a drawing, the illusion of distance is created by introducing into objects lines that converge toward a point in the background.

4. Parallax. This is the apparent relative movement of adjacent objects owing to change in the observer's position. As one moves forward, near objects appear to move in the opposite direction and distant objects in the same direction. In finer perceptions (as in the reading of a thermometer and many other scales). the same effect is produced by mere movement of the head or of the eyes. Because the eyes are more or less constantl in motion, the resulting parallax is highly useful in depth perception.

5. Blocking out of distant objects. Regardless of their relative sizes, near objects can block out distant objects. A coin held close to the eyes can block out a huge building several hundred feet away. Judgment of the nearness of the coin and the distance of the building depends on prior knowledge of the comparative true sizes of these objects.

VISUAL PATHWAY. The visual pathway includes those structures through which visual impulses pass in their course from the sensory receptors to the sensory areas of the brain. From the rods and cones, impulses are transmitted through bipolar neurons to ganglion cells whose cell bodies lie in the retina and whose axons leave the eye through the optic nerve. The axons pass through the optic chiasma, a crossing of the otic nerves, some fibers crossing to the opposite side, others remaining uncrossed (semidecussation). On passing through the optic chiasma, the fibers, now constitu-ting the optic tract, enter the brain and end in the lateral geniculate body of the thalamus. Here they synapse with neurons whose axons pass through the internal capsule to the visual centers, located in the cortex of the occipital lobes of the cerebrum. The nerve fibers that pass from the lateral geniculate body to the occipital cortex are called the optic radiation. In traveling from the rods and cones to the occipital cortex, a nerve impulse must pass through three neurons. The first has its cell body in the inner nuclear layer of the retina; the second is the ganglion cell of the retina; the third is a neuron with its cell body in the thalamus.

The visual field of each eye is divided into two regions: the medial or nasal half and the lateral or temporal half. For each eye, light rays from an object in the nasal half of the visual field fall on the temporal half of the retina; those from objects in the temporal half of the visual field fall on the nasal half of the retina. It should be noted that in the optic chiasma the nerve fibers from the nasal halves of the retinas cross and continue on to the thalamus; the nerve fibers from the temporal halves of the retinas do not cross but continue directly to the thalamus. In this way the visual center in the occipital cortex on each side receives impulses from the nasal half of the retina of one eye and the temporal half of the retina of the other eye. Accordingly, a lesion or injury to the retina or the optic nerve of one eye results in interference with (or loss of) vision in one eye only,

but owing to the peculiar course of the nerve fibers in the optic pathway, a lesion or injury to the nerve fibers in the optic chiasma, optic tract, optic radiation, or visual center of the cortex causes blindness in one half of each retina, a condition known as hemianopsia or half-blindness.

GROWTH AND DIFFERENTIATION

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INTRODUCTION :-

After the formation of all or, most organ rudiments of the embryo the main features of the organisation of the animal becomes clear. In other words, the morphological plan is established. By morphological plan we mean, the kind and no. of organs, their relative positions and general features of each organ structure... However, organ rudiments at this stage are not capable of performing their specific functions, on which depends the ability of the animal to live the independent existence. The cells of the organ rudiments lack the peculiar structures, that are necessary for specific functions; the organ rudiments are usually too small, and the animal as a whole is likewise far from the adult size. Of the developmental processes dealt withso far, may be grouped as pre-functional stages of development.

Next, a new phase of development sets in which brings the animal to its functional state. The main processes involved are growth and differentiation. Some new organs may appear in late stage of development, specially in animals passing through a larval stage, and the minor morphological adjustment may occur in the organs, formed earlier, but the process of growth and differentiation are pre-dominant.

G R O W T H :-

In ordinary life, growth is often identified with increase in height, from a biological view point, however, growth is an increase in the mass of living substance, i.e. due to synthesis of protoplasm or, of Apoplasmic Substances, Protoplasm includes both Nucleus and Cytoplasm of the cells. Apoplasmetic Substances are the substances which are produced by the cells which form the constituent part of the organism i.e. the fibres of connective tissue or, the matrix of bone and cartilage. Therefore, only weight can be the index of growth. The increase in linear dimensions may accompany increase of mass, but the connection is by no means a simple one.

Growth is the result of a preponderance of the anabolic (synthetic) over the catabolic (destructive) process in the organism. If synthesis and composition go on at the same rate, there is no increase in the bulk of the organism no growth. Under certain conditions, decomposition dominates over synthesis,

resulting in a decrease in the mass of living matter, which may cause degrowth. (Needham-1942).

By weighing a growing animal at a regular interval and plotting the weight against time on a diagram, we get a growth curve, showing the increase of the mass of the animal with time. The shape of the growth curve very often resembles the letter 'S': There is an initial part, where the curve rises very gradually, than a middle part, where curve rises steeply and the last part, where the rise of curve is again slowed down and the curve asymptotically approaches a horizontal line signifying the limit of growth in each particular case. A curve of this shape is known as sigmoid curve. If the increments of the growth for equal time intervel are measured, the entries during different periods of life of the same individual, may be estimated, the increase, taken as a difference between final and initial sizes (weights) of an animal for any period of time irrespective of other factors, is called absolute increase. However, it is not a correct indication of the rate of growth and cannot be used for comparing the growth at different periods of life or, for comparing the growth of different organisms. It is obvious that if a small animal and a big animal shows the same absolute increase in a given time, their rates of growth are not the same: the small animal has to grow at a greater rate to have the same absolute increase as the big one. The rate of growth is measured as relative increase. The increase related to the initial mass of growing substance.

Growth thus defined is in its essence an increase in geometrical progression, the increase being proportional to the intial quantity of growing substance. This is called exponential growth.

DIFFENTIATION :-

The term is somewhat ambiguous, in a broader, more general sense, the diffentiation is the process in which the cells or, the other parts of the organism became different from one another and also different from their previous condition. For example, while the neural plate as a whole is being induced by the roof of archenteron, its cells become different from both the presumptive epidermis and the parts of the blastoderm which gave rise to neural plate. In this broad sense, almost the whole of development may be said to be essentially a process of differentiation, and if an understanding is gained of how cells

of entrryo become different from one another and from their original condition, than such an understanding would be equivalent to understanding development, or, at least very essential part of it. At the same time, the term differentiation is used in narrow sense, in the sense of histological differentiation. Histological differentiation is the process, as a result of which the parts of the organism acquire the ability to perform their special functions. In the case of multicellular animals, the parts in question cells and group of cells.

The special functions of cells in this definition are distinguished from the basic functions of life, which are common to all living cells. Every cell is capable of performing the process of metabolism (Respiration, synthesis and so on), possesses to a certain degree, the ability for amoeboid movement shows fability, and is able to react to external stimuli. These functions are found in both undifferentiated and differentiated cells. Differentiated cells however, are able to perform than in such a way that other cells cannot. For example the nerve cells are capable of conducting nervous impulses to great distances at a high speed. The liver cells secrete bile, besides their other functions. The metanophores produce granuls of pigments in their cytoplasm.

The newral plate of an early enbryo, although differentiated in a general way, having become different from other parts of the emb is not differentiated histologically, since its cells is not yet capable of functioning as nerve cells.

The ability to perform special functions is dependent on the existence of specific mechanisms in the differentiated cells. These mechanisms are sometimes viable in the form of organoids of the cells, such as the myofibrils of muscle cells, the cillia of the epithelial cells of the tractea, and the long process of nerve cells. These trangible morphological properties of the cells are also called differentiations, as practice is legitimate as they are actually the visible of the process of differentiation.

FUNCTIONAL MECHANISM :-

The functional mechanisms of histologically differentiated cells are cytoplasmic. The building of these mechanisms therefore causes a shift in the relative volume of the nucleus and the cytoplasm. It is believed that even in the case of fully differentiated cells, the nuclei in all the various tissue of the animal's body have the same chromosomes and genes. In differentiated cells, the mass of cytoplasm increases, while the nuclei donot increase or donot increase in the same proportion. The ratiomass of cytoplasm to the mass of nucleus increases with differentiation.

The estimate may be made even more exact, it chemical substances and not morphological parts are taken into consideration, The basic substances of the nucleus are the chromosomes with DNA as their essential component. The cytoplasmic structures of the proteins, the enzymes, which are essential part of the functional mechanism of the cells are also protein. It is thus possible to substitute the amount of DNA for the basic structure of the cell and the amount of protein for its changing functional mechanisms. Direct measurement so that the relation, protein/DNA, changes with differentiation in agreement with expectation (Davidson and Leslie, 1950).

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CELLULAR RESPIRATION

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Respiration may be defined as generally any process that liberates chemical energy when organic molecules are oxidised. Where the process occurs within cells it is called internal, tissue or cell respiration. If it requires ozygen, it is aerobic respiration; whereas if the reaction takes place in the absence of oxygen, it is anaerobic respiration.

Tissue respiration must not be confused with the processes of acquiring and extracting ozygen from, and discharging carbon dioxide into, the environment. These are collectively termed external respiration, or preferably gas exchange

Organic molecules (usually carbohydrate or fat) are broken down bond by bond, by a series of enzyme controlled reactions. Each releases a small amount of energy, much of which is channelled into molecules of a chemical nucleotide called adenosine triphosphate (ATP).

ATP(Adenosine triphosphate)

ATP is composed of the purine adenine linked to the 5C sugar ribose and three phosphate groups (Fig). When the bonds of the two end phosphate groups of ATP are hydrolysed, the free energy yield for each is of the order of 30.6 Kj, whereas if the third phosphate group is hydrolysed the energy yield is only 13.8 kj. It is because of this that ATP and ADP (adenosine dephosphate) are popularly, though erroneously, believed to possess 'energy-rich' bonds (often signified ~).

ATP is the standard unit in which the energy released during respiration is stored. To make one ATP, molecule from ADP and phosphate 30.6 kj of energy are required. Therefore it can only be formed from reactions that yield more than 30.6 kj mol^{-1}. Any energy liberated in excess of 30.6 kj mol^{-1}, and all that from reactions that yield less that 30.6 kj mol^{-1}, cannot be stored in ATP and is lost as heat.

ATP is an instant source of energy within the cell. It is mobile and transports chemical energy to energy-consuming processes any where within the cell. When the cell requires energy, hydrolysis of ATP is all that has to occur for the energy to be made available. ATP is found in all living cells, and hence is often known as the universal energy carrier. ADP may be re phosphorylated to ATP by respiratory activity.

Cell Respiration in Outline

2. Cell respiration involves oxidation of a sub-strate to yield chemical energy (ATP). Organic compounds which are used as substrates in respiration are carbohydrate, fats and proteins.

When glucose is the substrate, its oxidation can be divided into three distinct phases; glycolysis (the Embden Meyerhof pathway); oxidative decarboxylation (Krebs, or citric acid cycle or TCA, tricarboxylic acid cycle); oxidative phosphorylation (respiratory chain incorporating hydrogen and electron transfer). Glycolysis is common to anaerobic and aerobic respiration, but the other two phases only occur when aerobic conditions prevail Details of each of the processes are to be found later in this chapter, but an outline is given below.

Glycolysis and the Krebs Cycles

During aerobic respiration glucose is oxidised by a series of dehydrogenations. At each dehydrogenation, hydrogen is removed and used to reduce a coenzyme:

$AH_2 + B \xrightarrow{\text{dehydrogenase}} A + BH_2$

reduced respiratory substrate	coenzyme (hydrogen acceptor)	oxidised respiratory substrate	reduced coenzyme

Most of these oxidations occur in the mitochondrion, where the usual coenzyme hydrogen acceptor is NAD (nicotinamide-adenine dinucleotide):

$$NAD + 2H \rightarrow NADH_2$$

or, more accurately,

$$NAD^+ + 2H \rightarrow NADH + H^+$$

$NADH_2$ then enters the respiratory chain to be reoxidised.

The Respiratory chain and oxidative Phosphorylation

$NADH_2$ is oxidised back to NAD and the hydrogen released is passed along a chain of at least five carrier substances to the end of the chain where the hydrogen combines with molecular oxygen to for water. The passage of hydrogen along this respiratory chain of carriers involves series of redox reactions. The energy released from some of these is sufficient to make ATP, a process called oxidative phosphorylation. The net yield per molecule of glucose completely oxidised to water and carbon dioxide is 38 molecules of ATP. sybtgesused frin ADP and inorganic phosphate. Glycolysis yields two ATP, Krebs cycle two ATP and the respiratory chain 34 ATP.

Glycolysis ~~and~~ in detail

Glycolysis represents a series of reactions in which a glucose molecule is broken down into two molecules of pyruvate (Fig-2). It occurs in the cytoplasm of cells, not in the mitochondria, and does not require the presence of oxygen. The precess may be sub-divided into two steps, first the conversion of glucose into fructose 1,6-diphosphate and secondly the splitting of fructose-1, 6-diphosphate into 3C sugars which are later converted into pyruvate. Two ATP molecules are used up for phosphorylation reactions in the first step, whilst four ATP molecules are produced in the second step. Therefore there is a net gain of two ATP molecules. Four hydrogen atoms are also released. Their fate will be discussed later. The equation of the overall

reaction is:

$$C_6H_{12}O_6 \rightarrow 2C_3H_4O_3 + 4H + 2ATP$$

glucose pyruvic acid (net gain)

The input and output of materials during glycolysis is shown in table-1

Table 1 Input and output of materials during glycolysis.

Total input	Total output
1.molecule of glucose(6C)	2 molecules of pyruvate(2x3C)
2 ATP	4 ATP
4 ADP	2ADP
2x NAD	2x $NADH_2$
2xP	2xH_2O

The ultimate fate of pyruvate depends on the availability of oxygen in the cell. If it is present, pyruvat will enter a mitochondrion and be completely oxidised into carbon dioxide and water (aerobic respiration). If oxygen is unavailable, pyruvate will be converted into ethanol or lactate (anaerobic respiration.)

Aerobic Respiration

There are two phases involved in aerobic respiration. First, if sufficient oxygen is available, each pyruvate molecule enters a mitochondrion where its oxidation is completed by aerobic means. This involves oxidative decarboxylation of pyruvate, that is the removal of carbon dioxide together with oxidation by dehydrogenation. During these reactions pyruvate combines with a substance called coenzyme A (often written CoA-S-H) to form acetyl coenzyme A. Sufficient energy is released to form an 'energy-rich' bond in the acetyl CoA molecule. In reality the complete reaction is much more complex than this description suggests and involves five different coenzymes and three different enzymes.

The overall reaction is:

$$CH_3COCOOH + CoA-H + NAD \longrightarrow CH_3CO\sim S-CoA + CO_2 + NADH_2$$

(acetyl CoA)

The $NADH_2$ formed as a result of acetyl CoA formation is collected and channelled into the respiratory chain in the mitochondrion.

The second phase is the Kribs cycle (named after its discoverer, Sir Hans Krebs). The acetyl component of acetyl CoA possesses two carbons and is passed into the Krebs cycle when acetyl CoA is hydrolysed. The acetyl component combines with oxaloacetate, a 4C compound, to form citrate (6C). This reaction requires energy which is provided at the expense of the energy-rich bond of acetyl CoA. A cycle of reactions follows during which the acetyl groups fed in by acetyl CoA are dehydrogenated to release four pairs of hydrogen atoms and decarboxylated to form two molecules of carbon dioxide. During the latter process oxygen is taken from two molecules of water and used to oxidise two carbon atoms to carbon dioxide. This is termed oxidative decarboxylation. At the end of the cycle oxaloacetate is regenerated and able to link up once again with another molecule of acetyl CoA, and so the cycle continues. One molecule of ATP, four pairs of hydrogen atoms and two molecules of carbon dioxide are released per molecule of acetyl CoA oxidised. The hydrogen atoms are accepted by NAD or FAD and are eventually passed into the respiratory chain. As two molecules of acetyl CoA are formed from one oxidised glucose molecule, Krebs cycle must rotate twice for each molecule respired. Therefore the net result is two ATP synthesised, four carbon dioxide liberated and eight pairs of hydrogen atoms released for entry into the respiratory chain (Fig-3).

The overall reaction for glycolysis, acetyl CoA formation and Krebs' cycle is:

$$C_6H_{12}O_6 + 6H_2O \longrightarrow 6CO_2 + 4ATP + 12 \boxed{\quad}H_2$$

Where $\boxed{\quad}$ = hydrogen acceptor.

Oxidative Phosphorylation and the Respiratory Chain

The pairs of hydrogen atoms removed from respiratory intermediates by dehydrogenation reactions during glycolysis and the Krebs cycle are ultimately oxidised to water by molecular oxygen with accompanying phosphorylation of ADP to form ATP molecules. This is accomplished when hydrogen, released from $NADH_2$ or $FADH_2$ is passed along a chain of at least five intermediate substances, which include flavoprotein, coenzyme Q and a number of different cytochromes, until at the end the hydrogen combines with molecular oxygen to form water. As a result of the passage of hydrogen the intermediate carriers undergo a series of redox reactions, and they are arranged in such a way that at three points in the chain, each time the hydrogen atoms are passed from one intermediate to another, a small amount of energy is liberated and incorporated into a molecule of ATP. (fig-4) In fact the initial part of the chain effects mainly hydrogen transfer whilst the latter portion operates purely electron transfer. During each redox reaction the iron ion is alternately in its oxidised (Fe^{3}) and reduced (Fe^{2}) forms. Finally, at the terminal stage, carrier Z, which contains copper and is commonly called cytochrome oxidase (cytochrome a/a3), promotes the reduction of molecular oxygen to water.

PHOTOSYNTHESIS : THE LIGHT REACTION

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Photosynthesis is essentially the only mechanism of energy input into the living world . Like energy-yielding oxidation reactions upon which all life depends photosynthesis involves oxidation and reduction. The overall process is an oxidation of water (removal of electrons with release of O_2 as a by-product) and a reduction of CO_2 to form organic compounds such as carbohydrates.

HISTORICAL SUMMARY OF PHOTOSYNTHESIS RESEARCH

Before the early eighteenth century, scientists believed that plants obtained all of their elements from the soil. In 1727, Stephen Hales suggested that part of their nourishment came from the atmosphere and that light participated somehow in this process. It was not known then that air contains different gaseous elements. In 1771, Joseph Priestley, an English clergyman and chemist, implicated O_2 (although this dephlogisticated air, as he called it, was not known to be a molecule) when he found that green plants could renew air made bad by the breathing of animals. Then a Dutch physician, Jan Ingenhousz, demonstrated that light was necessary for this purification of air.

Work of Lavoisier and others made it apparent that these gases were CO_2. Water was implicated by N.T. de Saussure when, in 1804, he made the first quantitative measurements of photosynthesis. The found that plants gained more dry weight during photosynthesis than could be accounted for by the amount by which the weight of CO_2 absorbed exceeded the with of O_2 released. He correctly attributed the difference to an uptake of H_2O. He also noted that approximately equal volumes of CO_2 and O_2 were exchanged during photosynthesis.

The nature of the other product of photosynthesis, organic matter, was demonstrated by Julius Sachs in 1864 when he observed the growth of starch grains in illuminated chloroplasts. The starch is detected only in areas of the leaf exposed to the light. Thus, the overall reaction of

photosynthesis was demonstrated to be as follows.

$$nCO_2 + H_2O + \text{light} - (CH_2O)n + nO2 \quad (R9\text{-}1)$$

In this reaction, (CHeO) is simply an abbreviation for starch or other carbohydrates with an empirical formula very close to this.

A further important discovery was that of C.B. van Niel, who in the early 1930s pointed out the similarity between the overall photosynthetic process in green plants and that in certain bacteria. Various bacteria were known to reduce CO_2 using light energy and an electron source different from water. Some of these use organic acids such as acetic or succinic acid as electron sources, while those to which van Niel gave primary attention use H_2S and deposit sulfur as a by-product. The overall photosynthetic equation for these bacteria was believed to be as follows.

$$nCO2 + 2nH_2S + \text{light} - (CH_2O)n + H_2O + 25 \quad (R9\text{-}2)$$

When R9-2 is compared with R9-1 above for green plants, an analogy can be seen between the rule of H_2S and H_2O, of C_2 and sulfur. This suggested to van Niel that the O_2 released by plants is derived from water, not from CO_2. This idea was supported in the late 1930s by work of Robin Hill and R. Scarisbrick, in England, that showed that isolated chloroplasts and chloroplast fragments could release O_2 in the light if they were given a suitable acceptor for the electrons being taken from water. Certain ferric (Fe^{3+}) salts were the earliest electron acceptors provided, and they became reduced to the ferrous (Fe^{2+}) form. This light-driven split of water in the absence of CO_2 fixation became known as the Hill reaction. It showed that whole cells were not necessary for at least some of the reactions of photosynthesis and that the light-driven O_2 release is not mandatorily tied to reduction of CO_2.

More convincing evidence that the O_2 released is derived from H_2O came in 1941 from results of Samuel Ruben and his associates. They supplied the green alga chlorella with H_2O containing O, a heavy, nonradioactive oxygen isotope that was detected with a mass spectrometer. The O_2 released in photosynthesis became labeled with ^1RO, thus supporting van Niel's hypothesis. For technical reasons,

Ruben's experiments could not prove that O_2 came entirely from H_2O, but later work of Alan Stemler and Richard Radner (1975) seems to provede such proof. We must, therefore, modify the summary equation for photosynthesis given in R9-1 to include two H_2O molecules as reactants:

$$nCO_2 + 2nH_2O + \text{light} \xrightarrow{\text{chloroplasts}} (CH_2O)n + nO_2 + nH_2O \quad \text{(R9-3)}$$

In 1951, it was found that a natural plant constituent, the vitamin B (niacin or nicotinamide)- containing coenzyme called nicotinamide adenine dinucleotide phosphate (commonly abbreviated $NADP^+$), could also act as a Hill reagent by accepting electrons from water in reactions occurring in isolated chloroplasts. One of two essential functions of light in photosynthesis is to drive electrons from H_2O to reduce $NADP^+$ to NADPH. The other function is to prove energy to form ATP from ADP and H_2PO4, as described below

This conversion of ADP and Pi to ATP in chloroplasts was discovered in the laboratory of Daniel arnon in 1954. Arnon found that ATP was synthesized in isolated chloro - plasts only during light, and the process become known as photosynthetic phosphorylation, or simply photophosphor"- lation, or simply photophosphorylation.

Photophosphorylation in chloroplasts accounts for much more ATP formation in leaves during the light then does oxidative phosphorylation in the mitochondria of those leaves, and so it is clearly of great quantitative signifi- cance.

CHLOROPLASTS: STRUCTURES AND PHOTOSYNTHETIC PIGMENTS

Chloroplasts of many shapes and sizes are found in various kinds of plants. They arise from tiny proplastids. Most chloroplasts are easily seen with the light microscope but their fine structure can be discovered only by electron

microscopy. Each chloroplast is surrounded by a double membrane system or envelope that controls molecular traffic into and out of them. Within the chloroplast is an other series of membranes that contains photosynthetic pigments.)

(Each of the internal membranes containing photosynthetic pigments seems to be the external surface of a flattened tube or sac, called a thylakoid (Greek thylakos, sac or pouch). In certain regions the thylakoids are stacked to form grana (single stack, granum). The longer thylakoids that connect one granum to another extend through the chloroplast matrix called the stroma, so these members are usually referred to as stroma thylakoids (Fig-1). Stroma thylakoids often extend into and make up part of one or more grana, and in those locations there is no apparent distinction between them and the grana thylakoids.)

(There is a cavity, which we call a channel, between the two membranes of each thylakoid. This channel is filled with water and dissolved salts, but it plays a special role in photosynthesis.

The pigments present in thylakoid membranes consist largely of two kinds of green chlorophylls, chlorophyll a and chlorophyll b. Also present are yellow to orange pigments classified as carotenoids. There are two kinds of carotenoids, the pure hydro carbon carotenes and the oxygen-containing xanthophylls.)

SOME PRINCIPLES OF LIGHT ABSORPTION BY PLANTS

To find out how light causes photosynthesis, we must learn something about its properties. Light has a wave nature and a particle nature. Light represents the part of radiant energy that has wavelengths visible to the human eye (approximately 390 to 760 nanometers, nm). This is a very narrow region of the electromagnetic spectrum.

The particulate nature of light is usually expressed in statements that light comes in quanta or photons, discrete packets of energy, each having a specific associated wavelength. The energy in each photon is inversely proportional to the wavelength, so the violet and blue wavelengths have more energetic photons than the longer orange and red ones. One mole (6.0×10^{23}) of photons has been called an

Einstein, although the term Einstein is now being discouraged because a mole is an SI unit and an Einstein is not.

A fundamental principle of light absorption, often called the Stark Einstein Law, is that any molecule can absorb only one photon at a time and this photon causes the excitation of only one electron.

Chlorophylls and other pigments can remain in an excited state only for short periods, usually a billionth (10^{-9}) of a second or even much less. The excitation energy can be totally lost by heat release as the electron moves back to ground state. A second way that some pigments including chlorophyll, can lose excitation energy is by a combination of heat loss and fluorescence. (Fluorescence is light production accompanying rapid decay of excited electrons.

(Photosynthesis requires that energy in excited electrons of various pigments be transferred to an energy-callecting pigment, a reaction centre which is a chlorophyll a).

Figure 9-6 (a) Absorption spectra of chlorophylls a and b dissolved in diethyl ether. The absorptivity coefficient used here is equal to the absorbance (optical density) given by a solution at a concentration of 1 g/l with a thickness (light path length) of 1 cm. (from F.Zscheile and C.Comar, 1941. Botanical Gazette 102.463.) (b) Absorption spectra of β-carotene in hexane and of lutein (a xanthophyll) in ethanol. The absorptivity coefficient used is the same as that described in Fog-9-6a (Data from F.Zscheile et al., 1942. plant physiology 17.331).

Shall explain later that there are two kinds of reaction centers in thylakoids, both of which consist of chlorophyll a molecules that are made special by their association with particular proteins and other membrane components. Figure-9-5 illustrates that the energy in an excited pigment can be transferred to an adjacent pigment, and from it to another pigment, and so on until the energy finally arrives at the reaction center.

(Chlorophylls are green because they absorb green wavelengths ineffectively and instead reflect or transmit them.

We can measure therelative absorbance of various wave lengths by a purified pigment with a spectrophotometer. A graph of this absorption as a function of wavelength is called an absorptionspectrum.

When we compare the effect of different wavelengths on the rate of photosynthesis, always making sure not to add so much energy of any wavelength that the process becomes saturated, we obtain an action spectrum.

The Emerson Enhancement Effect:

In the 1950s, Robert Emerson at the University of Illinois, was interested in why red light of wavelengths longer than 690 nm is so ineffective in causing photosynthesis.His research group found that if light of shorter wavelengths was provided at the same time as the longer red wavelengths, photosynthesis was even faster than could be expected from additing the rates found when either color was provided alone. This synergism or enhancement become known as the Emerson enhancement effect. We now realize two separate groups of pigments cooperate in photosynthesis and that such red wavelengths are absorbed only by one photosystem, called photosystem I (PS I). The second photosystem, photo system II (PS II), absorbs wavelengths shorter than 690 nm, and for maximum photosynthesis at longer wavelengths both system must function together.

Photosystems I and II: Composition, Functions and Locations in Thylakoids:

Analysis of the separated green bands shows that PS-I contains chlorophyll a, small amounts of chlorophyll b and some β-carotene attached by noncovalent bonds to several proteins. One of the chlorophyll a molecules is somehow made special by its chemical environment such that it absorbs light near 700 nm as well as at shorter wavelengths and so is called P700. It is P700 that is the reaction center for PS I and to which all surrounding chlorophyll a and β carotene molecules in that photosystem transfer their energy.

Photosystem II also contains chlorophyll a and β-carotene (connected to two major proteins), and again little chlorophyll b is present. The reaction center is P680, a chlorophyll a molecule in a chemical environment different from that of P700 or other chlorophylls a.

Besides these photosystems, two other major green bands can be separated from chloro[illegible]electrophoresis. Each contains both chlorophyll [illegible]

but very little β-carotene, all these pigments are bound to proteins. These green bands represent light-harvesting complexes of pigments and protein, one of which functions with PS I and the other mainly with PS II. Their function is to harvest light energy by absorbing it and transferring it to the proper photosystem, where it eventually reaches P700 or P680.

The thylakoids also contain electron carriers like plastocyanin, plastoquinone, cytochrome f, cytochrome b_6, cytochrome b_3.

A finalcomponent of thylakoids necessary for photophosphorylation is a complex of proteins called the ATPase or coupling factor (CF) complex. This complex can, under different conditions, either hydrolyze ATP to ADP and Pi or synthesize ATP from Pi and ADP by photophosphorylation.

The electron transport components of the model can be compared to a bucket brigade. Just as people in a bucket brigade rapidly move buckets of water toward a fire, so these elctron transport components move electrons rapidly from H_2O to $NADP^+$. First follow only the heavy arrows starting with H_2O(lower left). These arrows represent a pathway called monocyclic electron transport, because the electrons driven from H_2O to $NADP^+$ never cycle back.* The formation of ATP by this electron transport is called monocyclic photophosphorylation.

Photophosphorylation:

Formation of ATP also arises from a pathway of electron and H^+ transport partly separate from the noncyclic pathway described previously. This pathway involves PS I, ferredoxin, the cytochrome b_6 and f complex, plastoquinones, and plastocyanin but not PS II. Because the electron cycles from P700 back to P700, we call this cyclic electron transport. No H_2O is split, because PS II is not involved so no NADPH is ~~xpixx~~ formed. But ATP is produced by this cyclic-electron-transport pathway is therefore, called cyclic photophosphorylation.

Reduction Potentials and the Z-scheme:

Some compounds can easily accept electrons and are easily reduced, but such compounds only give up electrons with difficulty. Other compounds do not readily accept electrons but give

them up easily. In thermodynamic terms that we can express quantitatively, reactions involving the former compounds have relatively positive reduction potentials, and reactions involving the latter compounds have relatively negative reduction potentials. The symbol used to express the standard reduction potential at pH 7 is E'_o. Only if the E'_o value for a reaction involving one compound is more negative than that for another compound can the first compound be expected on thermodynamic grounds to readily donate an electron to the second.

For electron transport from H_2O to $NADP^+$, H_2O is difficult to oxidize, because O_2 atracts electrons and protons so strongly (is so easy to reduce).

By isolating suspected components of the electron-transport pathway from H_2O to $NADP^+$ and measuring E'_o values for redox reactions in which they participate, biochemists attempted to place each component next to another with a similar E'_o value. The goal was to arrange them such that electrons reasonably flowed downhill energetically, from more negative to less negative (or more positive) E'_o value. The problem became easier after it was recognised that two photosystems were involved and that two photons acted separately to push an electron partway "uphill" on the energy scale. This led to a Z-scheme of electron transport first proposed by R. Hill and F. Bendall in 1960. Our is based partly on Z-scheme models described recent books and reviews e.g. Kok (1976).

Photosynthesis
– R. Mesa

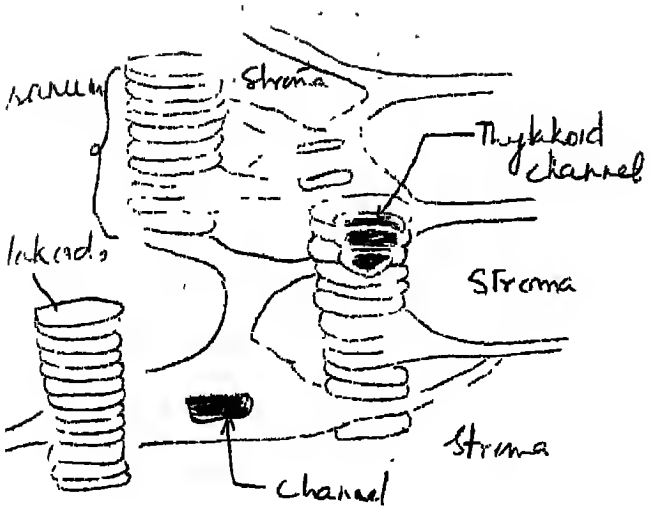

Fig 1. A 3-dimensional interpretation of the arrangements of the internal membranes of a chloroplast emphasizing the relation between stroma thylakoid and grana.

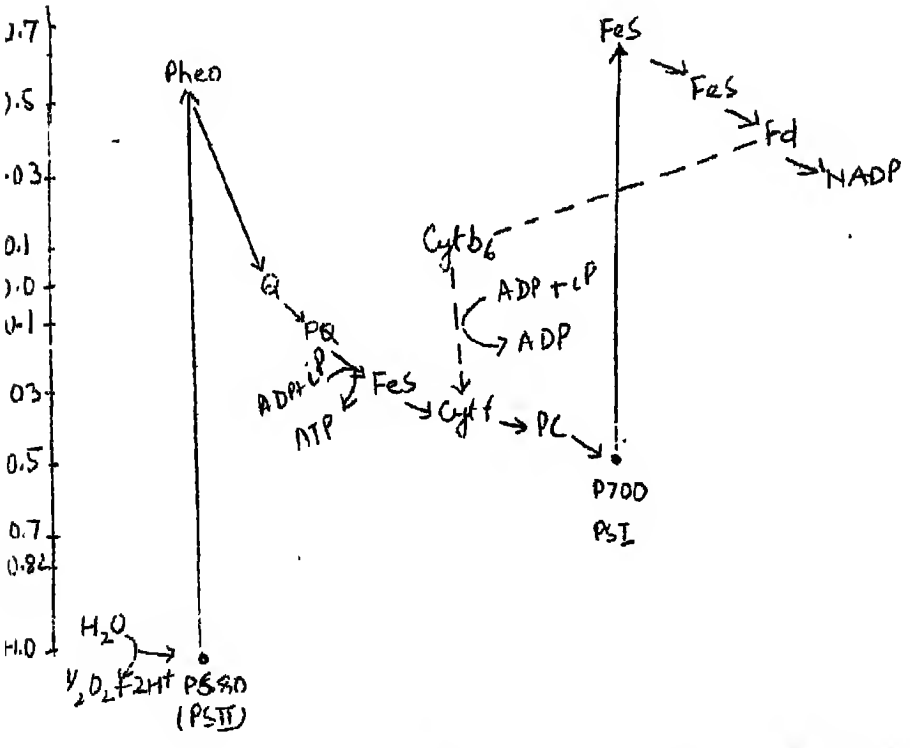

Fig 2 The Z-scheme of electron transport showing photophosphorylation.

. IELD AND HLREARIUM TECHNIQUES AND MAINTENANCE

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A herbarium is a collection of plants that usually,have been pressed,dried,mounted on sheets and arranged in accordance with any accepted system of classification for future reference and study.

There are three different means of handling fresh material for processing into herbarium specimens. The most easy and satisfactory method is to press each plant as it is collected,in between the folded blotting papers or sheets of newsprint. The second method is to accumulate the material in a Vasculum(a metal collecting can). But plants should be pressed as soon as opportunity permits. The third method is to carry collected specimens in a rucksack. They are then pressed as soon as possible after return to headquarters.

At the time of collection care should be taken to have the specimens in flowering stages. Vegetative parts without flowers are absolutely useless for herbarium as their identification becomes almost impossible. Certain items of equipments are indispensable while attending an excursion for collection of material (i)a strong knife (ii) a pair of pruning shears, (iii)a collecting pick, (iv) a plant press containing blotting papers, (v) a field record book with voucher numbers, and (vi) a small note book.

Drying technique: The collected specimens are placed in between the blotting papers which are then placed one above the other and then tied tightly in a field press, which is efficient in holding the specimen under a constant and firm pressure. The press is locked up for twenty-four hours- the 'sweating period'. After the sweating period the press is opened,the pressing papers are changed and the specimens are rearranged. The rearrangement

of specimens is very important as during this process the plant parts can be put in a desired position. The press is locked up again and allowed to remain as such for forty-eight to seventy-two hours. This process is repeated for several time until the specimens become completely dried.

Mounting and levelling of the specimen: After drying the specimens should be mounted on mounting papers or herbarium sheets. These sheets must be of good quality and heavy to support the specimens as a permanent record. The standard size of a herbarium sheet is 29X 42 cm. The specimens are fixed to the sheets with the help of quick drying adhesives. Each herbarium sheet should be provided with a level (6X10cm), either pressed or printed on the lower right-hand corner. The label should give the following information:

FLORA OF.....

Voucher No..... Date of collection.....

Name .....

Family.....

Habit.....

Locality..... Attitude.....

Collection.....

Remarks.....

Preservation of herbarium sheets: If not properly preserved, the insects and fungi do irreparable damage to the herbarium sheets. The most common pests are the silver fish, herbarium bettle, etc. and the fungus is is Eurotium herbariorum. Different chemicals, such as cyanide gas, paradichlorobenxene, DDT, naphthaflaker are generally used as preservatives.

PLANT IDENTIFICATION

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The identification is the determination of a taxon "as being identical with or similar to another and already known element". Usually the first step essential in identification of plant is the identification of the family to which it belongs. This step is accomplished by use of artificial key to families. Once the family is determined, by use of the key to genera, generic name is determined. Then by means of the key to species, specific identity of the plant is known. Identification is usually done by the utilization of taxonomic literature, floras, manuals, check lists, monographs and revisionary work on various taxa.

In identification of an unknown plant keys are useful devices. There are various types of keys in use but the most convenient and acceptable type of key is dichotomous key. In this type of key at every stage a choice must be made between two contrasting alternatives, one of which will fit the situation and the other will not apply. Various terms used in plant morphology are explained in the glossary provided in the appendix. A brief attention is drawn here to certain features that may cause difficulty when using the key. For identification a reasonably complete specimen, with vegetative parts, flowers (if unisexual both male and female flowers) and fruits are required.

Certain deciduous plants flower when they are without leaves. In such cases leaf phyllotaxies can be determined by examining the leaf-scars. Stipules should be looked for on young shoots, as they are often deciduous. Punctate pellucid glands is another distinctive feature to look for, which can be best observed by holding a leaf against light, and so also the presence of milky or coloured sap.

The arrangement of perianth (aestivation), which is sometimes a valuable family character, should be observed in the bud, whereas placentation at full anthesis. An actinomorphic flower has sometimes only one plane of symmetry as in Brassicaceae and some Papaveraceae and a zygomorphic flower has only one plane of symmetry.

The perianth may be in one series or more series or absent. When in more than one series, it should be observed if the series resemble one another in form, colour and texture or they are differentiated in calyx and corolla. In some cases (e.g. Papaver) the calyx is caducous and is thrown off as the flower opens. In such cases observation in bud can give a correct idea of the situation. In some cases, as in many Apiaceae, Asteraceae and Rubiaceae the calyx is reduced to a rim, minute teeth or hairy pappus. Such flowers are treated as having a distinct calyx and corolla. In some cases (e.g. Nyctaginaceae) the calyx is petaloid structure and it should not be confused with corolla. In some cases an epicalyx is present outside the calyx (e.g. some Malvaceae).

A nectar secreting dise may be present in many flowers (e.g. Rutaceae) or nectar is secreted by separate glands (e.g. Geranium) or nectar is secreted by the perianth or in sace and spurs developed on the corolla (e.g. some Ranunculaceae).

The stamens are antipetalous i.e. opposite the perianth segments as in Chenopodiaceae and Amaranthaceae or the stamens of the outer whorl are opposite the petals, a condition known as obdiplostemony (e.g. Caryophyllaceae).

The placentation is of vital importance in identification and it can be best observed by cutting one ovary transversely and another longitudinally by a razor blade. Attachment of ovules can be sometimes seen more easily by slitting the ovary wall with a sharp needle (e.g. Asteraceae, Cyperaceae).

It is sometimes difficult to determine number of carpels in a syncarpous ovary. In such cases number of styles and stigma, the number of placentae in parietal placentation, and the number of locules in an ovary with axile placentation are indicator of basic carpel number.

It is always preferable to examine living material but floral structures can also be examined if a pressed flower is boiled in water for a couple of minutes and then dissected in a drop of water under a dissecting microscope.

With the help of the key given in the following pages, selected families of the flowering plants, described in this book can be easily identified. The key is indented type and dichotomous throughout. The main key is arranged in groups. Each pair of lead (alternative statement) is numbered, and each lead of a pair is given a distinguishing letter (a,b).

KEY TO THE GROUPS

1a. Cotyledons two; leaves usually with reticulate venation; flowers usually pentamerous or tetramerous; vascular bundles of the stem usually arranged in a ring; tap root usually present.

(DICOTYLEDONS).

2a. Flowers with two distinct whorls of perianth.

3a. Corolla of distinct petals[1].

4a. Flowers hypogynous.

5a. A conspicuous disc is present at the base of the ovary

Group 2.

5b. Disc is absent.

Group 1.

4b. Flowers perigynous or epigynous.

Group 3.

3b. Corolla of united petals.

6a. Ovary inferior.

Group 4.

6b. Ovary superior.

7a. Carpels more than two.

Group 5.

7b. Carpels two. Group 6.

2b. Flowers with one whorled of perianth, usually sepaloid[2].

Group 7.

1b. Cotyledon one; leaves usually with parallel venation; flowers usually trimerous; vascular bundles of the stem scattered; tap root usually absent.

(MONOCOTYLEDONS)

Group 8.

GROUP KEYS

Dicotyledons

GROUP - 1

Flowers mostly regular and bisexual; petals distinct; stamens hypogynous; ovary superior.

1a. Aquatic plants with peltate leaves.

Nymphaeaceae

quatic then without peltate

ulate leaves; connective
ed; endosperm of the seed

Annonaceae

ulate leaves; connective
the seed watery fleshy.

Magnoliaceae

amerous, not trimerous.
s carpels.

Ranunculaceae

carpels.

Fumariaceae

Violaceae

Papaveraceae

Brassicaceae

; androphore and

Capparidaceae

; androphore and

Violaceae

capsule dehiscing by

Caryophyllaceae

s; capsule dehiscing

Portulacaceae

5b. Ovary multilocular.

13a. Anthers one-celled.

Malvaceae

14b. Stamens many, more or less distinct.

Tiliaceae

G R O U P - 2

Sepals distinct or united; a conspicuous disc is present; stamens usually definite, inserted upon or at the outer or inner base of the disc; ovary superior.

1a. Leaves aromatic, glandular punctate.

Rutaceae

1b. Leaves neither aromatic nor glandular punctate.

2a. Climbers, usually with tendrils.

Vitaceae

2b. Trees, shrubs or herbs without tendrils.

3a. Flowers bisexual, disc usually annular adnate to the stamens.

4a. Leaves simple and stipulate; fruit a schizocarp.

Geraniaceae

4b. Leaves compound and exstipulate; fruit a capsule or drupe.

5a. Stamens obdiplostemonous; may be united only at the base.

Oxalidaceae

5b. Stamens not obdiplostemonous; united into a tube around the style.

Meliaceae

3b. Flowers usually unisexual, disc tumid, adnate to the base of calyx or lining its tube.

6a. Fruit capsular or indehiscent, sometimes winged.

Sapindaceae

6b. Fruit a one-celled one-seeded drupe.

Anacardiaceae

GROUP - 3

Sepals united, rarely free; often adnate to ovary; stamens perigynous, usually inserted on or beneath the outer margin of the disc; ovary often inferior.

1a. Ovary of one carpel with marginal placentation; fruit a legume.

Fabaceae

1b. Ovary of two or more carpels; placentation not marginal; fruit never a legume.

2a. Herbs climbing with the help of tendrils.

Cucurbitaceae

2b. Herbs shrubs or trees with out tendrils.

3a. Leaves stipulate.

Rosaceae

3b. Leaves exstipulate.

4a. Placentation parietal.

Cactaceae

4b. Placentation not parietal.

5a. Ovary unilocular with two to five pendulous ovules.

Combretaceae

5b. Ovary usually two or more locular.

6a. Leaves with pellucid aromatic glands.

Myrtaceae

6b. Leaves with out pellucid aromatic glands.

7a. Fruit a many-seeded capsule.

Lythraceae

7b. Fruit a schizocarp splitting into two mericarps.

Apiaceae

GROUP - 4

Corolla gamopetalous; stamens usually as many as corolla lobes; ovary inferior.

1a. Leaves opposite and stipulate.

Rubiaceae

1b. Leaves alternate and exstipulate.

Asteraceae

GROUP - 5

Corolla gamopetalous; stamens as many or twice as many as the corolla lobes; carpels more than two; ovary superior.

Sapotaceae

GROUP - 6

Corolla gamopetalous; stamens as many as or fewer than corolla-lobes; carpels two; ovary superior.

1a. Flowers actinomorphic; stamens as many as the corolla-lobes.

2a. Leaves usually opposite.

3a. Pollen granular, transferred directly from anthers; corona absent.

Apocynaceae

3b. Pollen often in pollinia, transferred by means of specialized translators; corona present.

Asclepiadaceae

2b. Leaves generally alternate.

4a. Ovules one or two per loculus.

5a. Sepals free; corolla lobes contorted and infolded.

Convolvulaceae

5b. Sepals connate; corolla lobes imbricate.

Boraginaceae

4b. Ovules numerous in each loculus.

Solanaceae

1b. Flowers zygomorphic; corolla usually two-lipped; stamens fewer than corolla lobes.

6a. Ovules many in each locule.

7a. Trees, shrubs or climbers with compound leaves; seeds winged.

Bignoniaceae

7b. Herbs or shrubs with simple leaves, seeds wingless.

8a. Capsule opening elastically; seeds usually on hooked funiculus.

Acanthaceae

8b. Capsule not elastic; seeds not on hooked funiculus.

9a. Flowers axillary; corolla ventricose, sub-two-lipped.

Pedaliaceae

9b. Flowers in racemes or spikes; corolla not ventricose usually two-lipped.

Scrophulariaceae

6b. Ovules one or two in each locule.

10a. Style gynobasic; fruit usually of four one-seeded nutlets; corolla strongly bilabiate; calyx often two-lipped.

Lamiaceae

10b. Style terminal; fruit a berry or drupe; corolla less strongly zygomorphic; calyx nearly actinomorphic, not two-lipped.

Verbenaceae

GROUP - 7

Flowers usually with one whorl of perianth, usually sepaloid, or none.

1a. Stems jointed; leaves reduced to whorls of scales.
Casuarinaceae

1b. Stems not jointed, leaves expanded.

2a. Ovary inferior; branch parasites.
Loranthaceae

2b. Ovary superior; not branch parasites.

3a. Flowers usually bisexual or polygamous.

4a. Leaves stipulate; stipules sheathing.
Polygonaceae

4b. Leaves exstipulate.

5a. Perianth scarious; stamens usually with interposed staminodes.
Amaranthaceae

5b. Perianth sepaloid; staminodes not present.
Chenopodiaceae

3b. Flowers usually unisexual.

6a. Ovary trilocular; fruit schizocarpic; seeds carunculate.
Euphorbiaceae

6b. Ovary unilocular; fruit a syncarp of confluent pericarps and perianths; seeds not carunculate.
Moraceae

MONOCOTYLEDONS
GROUP - 8

1a. Trees, shrubs or scramblers with large plicate or pinnately divided leaves; flowers nearly sessile, in fleshy spikes or panicles with spathe-like bracts.
Arecaceae

1b. Not as above.

2a. Aquatic herbs, carpels free.
Alismaceae

2b. Terrestrial plants[1], carpels usually fused.

3a. Ovary inferior.

4a. Flowers in spadix.
Musaceae

4b. Flowers not in spadix.

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1. A few Araceae are also aquatic herbs.

5a. Placentation parietal.

Orchidaceae

5b. Placentation not parietal, usually axile.

6a. Fertile stamen one, the others often transformed into petal-like staminodes.

Zingiberaceae

6b. Fertile stamens six, in two trimerous whorls.

Amaryllidaceae

3b. Ovary superior.

7a. Perianth well developed.

8a. Leaf bases sheathing, filaments bearded.

Commelinaceae

8b. Leaf bases not sheathing; filaments not bearded.

Liliaceae

7b. Perianth scarious or redeced to bristles, hairs or lodicules or none.

9a. Flowers usually unisexual, on a spadix; fruit a berry.

Araceae

9b. Flowers uni-or bisexuzl; in spikelets; fruit indehiscent.

10a. Leaf phyllotaxis 1/2; leaf sheaths with usually free margins; culms sulms cylinderical; spikelets subtended by a pair of sterile bracts (glumes); each flower enclosed between a membranous bract (lemma) and adaxial bracteole; perianth reduced to lodicules.

Poaceae

10b. Leaf phyllotaxis 1/3; leaf sheaths closed; culms usually triangular; spikelets usually not subtended by sterile bracts; each flower subtended by a single membranous bract; perianth represented by bristles, hairs, scales, or none.

Cyperaceae

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M I T O S I S

Dr. G.V. Gopal
Lecturer in Botany

Mitosis is a mechanism by which the cell distributes. in equivalent amounts, the different components that have been duplicated during the interphase. Prophase, metaphase, anaphase and telophase are characterized by morphological changes that take place in the nucleus and the cytoplasm.

In prophase chromosomes appear as thin threads that condense by coiling and folding. Each chromosome contains two chromatids which will be the future daughter chromosomes. With condensation each chromatid shows the centromere or kinetochore. The nucleolus tends to disintegrate and disappears at the end of prophase. In the cytoplasm the spindle is formed between the asters (and centrioles) that move toward the poles. Centrioles replicate at interphase during the S period.

At the beginning of metaphase (prometaphase) the nuclear envelope disintegrates and there is mixing of the nucleoplasm with the cytoplasm. Chromosomes become attached to the microtubules of the spindle and are oriented at the equatorial plate. The spindle has continuous microtubules and Chromosomal ones. Animal cells have the spindle shown in (astral mitosis). In plant cells centrioles and asters are absent (anastral mitosis).

In anaphase the daughter chromosomes, led by the centromere, move toward the poles. The spindle fibers shorten one third to one fifth the original length.

In telophase chromosomes again uncoil; the nuclear envelope is reformed from the endoplasmic reticulum; and the nucleolus reappears.

Cytokinesis is the process of separation of the cytoplasm. In animal cells there is a constriction at the equator that finally results in the separation of the daughter cells.

During prophase and metaphase the chromosomes undergo a process of condensation which is reversed during telophase. This process is related to the folding and unfolding of the unit fiber that constitutes the basic structure of the chromosome. The condensation cycle is specific for each chromosome and probably depends on special regions (folders)

spaced along the unit fiber. It is generally believed that each chromosome is made of a single strand of DNA during the G_1 period. The single strand duplicates during the S period, and later on (G_2 and prophase) each chromosome is double (two chromatids). Experiments involving X-irradiation and the action of DNA-ase tend to confirm the single strand model of the chromatid.

The centromete or kinetochore is a special differentiation of the chromosome, situated at the primary constriction. It is the site of implantation of the microtubules of the spindle, it has a cup-like shape (0.20 to 0.25 um); and it is made of non-chromatin material. The kinetochore may be a nucleation centre for the polymerization of tubulin, the protein of microtubules.

The mitotic apparatus comprises the spindle and the asters which surround the centrioles. The spindle is made of the chromosomal fibers, the continuous fibers, and the interzonal fibers, the latter are observed at anaphase and telophase between the daughter chromosomes. Study of the mitotic apparatus can be performed by electron microscopy, but in the living condition polarization microscopy is most useful in following the development of the various fibers.

In plant cells the interzonal region of the spindle is transformed into the phragmoplast, which is the precursor of the cell plate. Spindle fibers are dynamic structures that are assembled and disassembled. Microtubules are depolymerized in the cold and become more developed in heavy water.

The protein tubulin is composed of dimers of 110,000 to 120,000 daltons. Colchicine and other drugs bind to tubulin. preventing its polymerization and the formation of microtubules. In this way mitosis is stopped at metaphase. The mechanism by which some microtubules shorten during anaphase is not completely known, but is probably by depolymerization at the polar ends.

Elongation and shortening of microtubules seem to be the two major mechanism by which the chromosomes are moved towards the poles. The microtubules attached to the kinetochores exert considerable pulling force. It is calculated that 30 ATP molecule of energy are required for a chromosome to move from the equator to the pole. The most favored explanation for the mechanical action of the spindle is the so-called assembly-disassembly hypothesis. During anaphase the assembly of microtubules of the continuous fibers may cause elongation, with separation of

the poles and "pushing" of the chromosomes. The disassembly of microtubules of the continuous fibers may cause shortening and "pulling" of the chromosomes.

Cytokinesis or cell cleavage differs considerably in animal and plant cells. In the former, separation of daughter cells is produced by an equatorial construction which involves a contractile mechanism at the cell cortex. This is achieved by a system of actin-like microfilaments. A dense structure called the midbody may be formed.

In plant cells cytokinesis starts with the formation of the phragmoplast, which comprises the interzonal microtubules and Golgi vesicles. This structure is transformed into the cell plate, which separates the territories of the daughter cells. Within the cell plate the primary cell wall is produced by a secretory mechanism consisting mainly of the production of pectin, which is contained in Golgi vesicles.

-XOOOOOX-

M E I O S I S

Meiosis is a special type of cell division persent in germ cells of sexually reproducing organisms. It consists of a single duplication of the chromosomes, followed by two consecutive divisions. The result is four haploid cells. Meiosis may be : (1) terminal or gametic, occuring immediately before the formation of the gametes; (2) intermediary of sporic, taking place sometime between fertilization and the formation of the gamets (found in higher plants); or (3) initial or zygotic, occuring immediately after fertilization (found in fungi;

Meiosis is divided into Division 1 and Division II. Division I has a long prophase during which the homologous chromosomes pair closely andinterchange hereditary material. The stages of leptonema, zygonema, pachynema, diplonema, and diakinesis are recognized. Chromosomal pairing occurs at zygonema and is completed a pachynema, giving rise to the bivalent that is formed of four chromatids (tetrad). Between the homologues there is a 0.1 to 0.2 um space occupied by the synaptonemal comple (see below). At pachynema, transverse breaks are produced and ther is interchange (i.e. recombination) between two of the homologous chromatids, while the other two remain intact. At diplonema, the phenomenon or recombination, expressed morphologically as chiasmata, is also referred to as crossing over. The number of chiastmata varies in different chromosomes. In diakinesis,

contractiohof the chromosomes is accentuated, and chiasmata move toward the ends of the chromosomes (terminalization). The rest of the meiotic process is very similar to mitosis.

The essence of the meiotic process is the formation of four nuclei, each differing from one another, in which each chromosome of the parent is represented once. As a result of the chiasmata in crossing over, the chromosomes usually do not consist of either completely maternal or completely paternal material, but of alternating segments of each. For example, all segments of chromosome A, between the centromere and the chiasma, effect a reductional division in anaphase I and an equational division in anaphase II. On the other hand, the segments located between the distal end of the chromosome and the chiasma effect a reduction in anaphase II.

Meiosis is, therefore, a mechanism for distributing the hereditary units (genes), permitting their random independent recombination. Crossing over provides a means by which genes of different chromosomes can be brought together and recombined. If this process did not take place, the evolution of the species would be suspended by unalterable chromosomes, and organism would not have their characteristic diversity.

The study of meiosis is a prerequisite for the understandin of the chromosomal basis of genetics. Only after the process of meiosis is understood will its significance in hereditary phenomena become apparent.

SYNAPTONEMAL COMPLEX AND RECOMBINATION

Two of the most important phenomena to take place during meiotic prophase are the linear pairing of the chromosomes and the interchange of segments between two of the homologous chromatids by crossing over or recombination. Studies of spermatocytes and oocytes with the electron microscope have demonstrated the presence of an axial differentiation of the meiot chromosomes at the time of pairing. This special structure is generally called the synaptonemal complex (SC) (other designations are chromosomal core, synaptinemal complex, or axial

The synaptonemal complex is a special structure, protein in nature, that develops during meiotic prophase in all eukaryotes It is composed of two lateral and one central component. The lateral components of the SC appear in each of the homologues, and the central component becomes evident during pairing. It seem possible that it is inside this central component that the close

pairing needed for the recombination of the DNA molecules of homologous chromatids takes place. This pairing may be achieved via thin DNA fibers that pass across the SC. At diplonema the SC is shed from the bivalents, with the exception of the regions in which the repelling homologues are held together by a chiasma. Thus, a chaisma contains a piece of SC that will utlimately disappear and be replaced by a chromatin bridge.

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MITOSIS

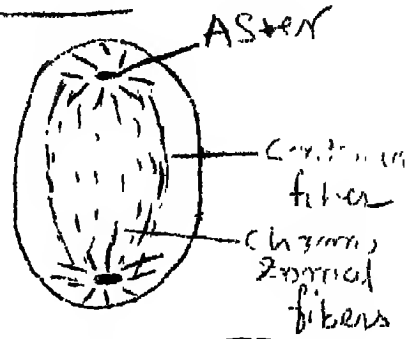
Difference of Mitosis in Animal cell and Plant Cell.

(A) Interphase

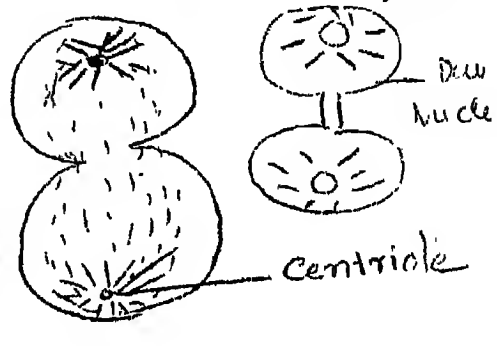
Animal cell :-

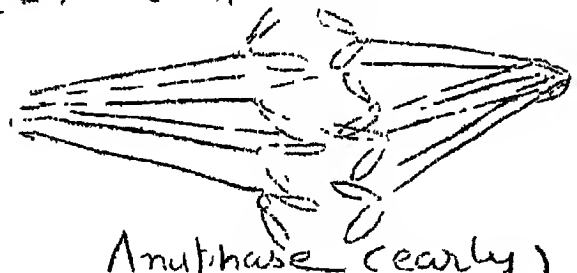
(B) (C)

Prophase



(D) Metaphase



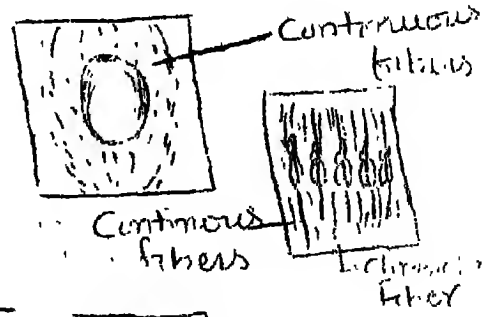


Anaphase (early)

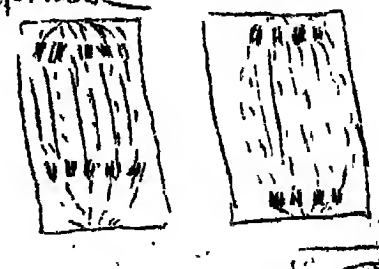
Plant cell :-

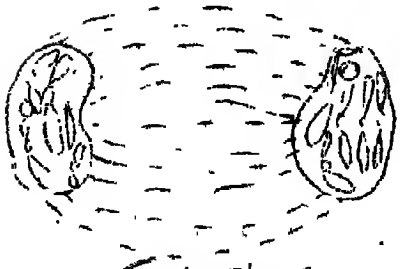
(E)

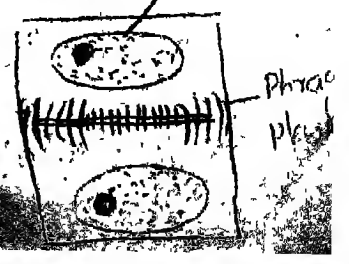
(F)



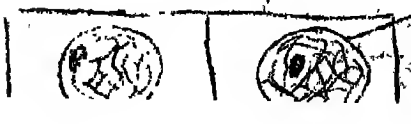
Late Anaphase



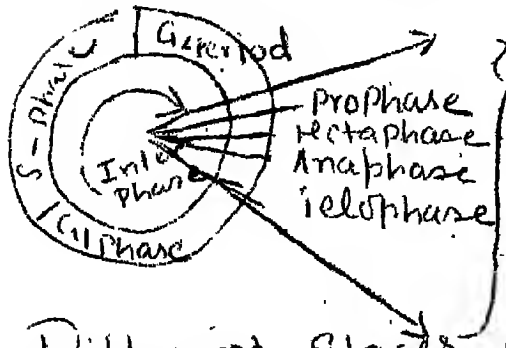




Telophase



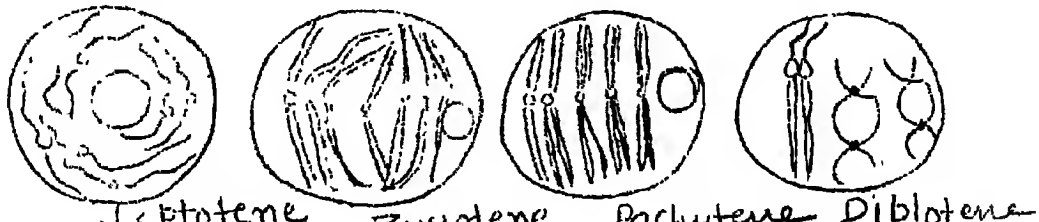
Schematic Representation of cell cycle

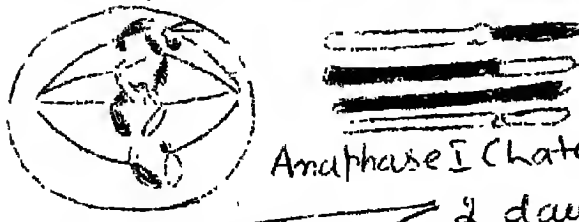


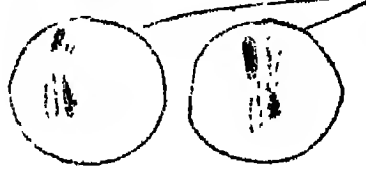
Different Stages of Meiosis

Meiosis occurs in 2 Stages i.e Meiosis-I, Meiosis-II

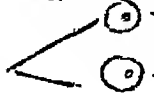
PROPHASE I :-







Meiosis — II is exactly like Mitosis so, as a result from 2 daughter cells divide and 4 cells are formed.



ENDOCRINE SYSTEM

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The endocrine system consists of a number of glands located in different parts of the body that have no anatomical continuity. However, the whole system forms a functional unit having a direct or reciprocal relationship. The endocrine system is under the control of nervous system. The neuroendocrine relationships have been studied in a number of vertebrates. An intimate relation of endocrine system with the autonomic and central nervous system via hypothalamus has been revealed. The hypothalamus serves as a relay station. The nervous system and the endocrine system are two important co-ordinating system which help in the function of integration between external and internal environment of the body.

The ductless glands of the endocrine system produces/ secretes hormones which passes directly from the gland cells into the blood stream for transmission to various "target" tissues. Hormones are information transferring molecules. Sometimes the target organ for a particular hormone may be an endocrine organ itself and hence the hormone is called as trophic hormone. All trophic hormones are secreted by the anterior pituitary.

GENERAL CONSIDERATIONS OF HORMONES:

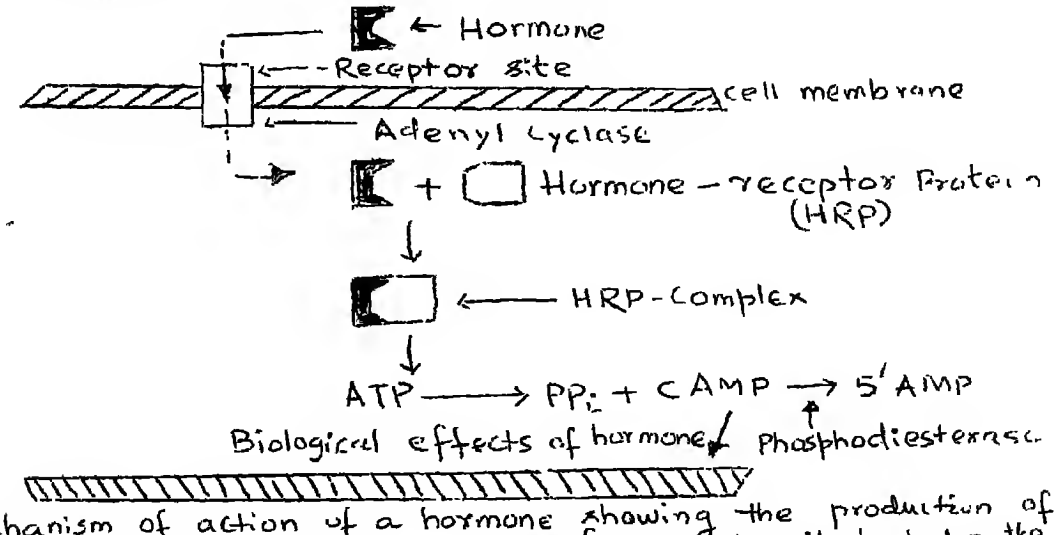
(1) Hormones may be peptides, proteins, glycoproteins amino acid derivatives or steroids (2) It acts as bodily catalysts resembling enzymes in certain respects. (3) Secreted to blood stream prior to use (4) Produced in an organ other than that in which they finally effect the action. (5) Produces satisfactory action even in low concentration. (6) Easy solubility low molecular weight, easily diffusible and no cumulative (continued) action are some of the essential properties of hormone. (7) Specific secretory stimuli are necessary for the secretion of hormones. However, the amount of secretion depends upon the nature and intensity of stimulu

MODE OF ACTION OF HORMONES:

Physiologically, a hormone is considered as a carrier of information to modulate the function of certain tissues as per the needs of the body. These tissues are the receptor or the target tissues. In order to understand the

mode of functioning of the hormones Certain fundamental questions comes to our mind. How does a given receptor cell selectively recognize the hormonal message intended for it? What is the mechanism employed by the cell to modify its own function to respond accordingly? It should be first appreciated that the hormonal concentrations in the body are exceedingly small, even then the magnitude of their response is quite big. How a signal is amplified to trigger a response is a matter of experimental study. The harmonal message is specifically recognised, and then translated into signals capable of modifying the programme of the receptor cell.

In the nineteen-fifties, Sutherland and his associates suggested that adrenaline (a hyperglycaemic hormone) must play a part to increase the activity of the enzyme responsible to convert glycogen to glucose (hepatic glucose production). This enzyme happens to be phosphorylase which catalyzes hydrolysis of glycogen with the production of glucose-1 phosphate. The hormone triggers the formation of a substance which activates phosphrylase and this substance was identified as cyclic adenosine-3", 5' monophosphate (cyclic MP). It is known that cAMP is formed from its precursor, ATP, under the catalytic influence of a specific enzyme adenyl cyclase. The enzyme is ubiquitous in nature and has been found in many different types of cell (chiefly in cell membrane). There are receptors on the cell surface each of which is specific for a single hormone and the response of a given tissue to a hormone depends on the presence of a specific receptor site. There seems to be some kind of a coupling factor between the receptor and the enzyme adenyl cyclase.



(Mechanism of action of a hormone showing the production of cyclic AMP. The hormone acts at a specific receptor site located in the plasma membrane)

Many hormones exert their action by way of formation of cyclic AMP in the receptor cells. Hence C-AMP is called as 'second messenger' owing to its role as intracellular intermediary. Cyclic AMP is broken down in the cells by enzyme phosphodiesterase which converts it to 5'-AMP. The hormone must produce increased quantity of C-AMP present in the receptor cell. Addition of exogenous cAMP to the system will produce specific biological effects of the hormone in all respects.

The endocrine system consists of the following glands:

1 Pituitary gland.
1 Thyroid gland.
4 Parathyroid glands.
2 Adrenals or Supra-renal glands.
The islets of Langerhans in the pancreas.
2 Testes in the male,
2 Ovaries in the female,
Placenta in the female.
1 Thymus.
1 Peneal gland or body.

Pituitary gland (Hypophysis):-

It is a composite gland situated at the base of the brain just behind the optic chaisma as an extension from the floor or the hypothalamus in man. Anatomically is divided into three parts - anterior lobe, posterior lobe and the intermediate lobe.

i) Anterior pituitary : The anterior pituitary is also called adenohypophysis. It is highly secretory in activity. Six hormones have so far been isolated from this lobe. They are :

Adrenocorticotrophic hormone (ACTH) controls the synthesis and secretion of hormones from Adrenal cortex.

Thyroid stimulating hormone (TSH) controls the synthesis and secretion of thyroid hormone.

Follicle-stimulating hormone (FSH) controls ovarian development; responsible for maturation of follicles in females and controls testicular development, spermatogenesis in males.

Luteinizing hormone (LH) or interstitial-cell stimulating hormone (ICSH) controls the secretion of estrogens and progesterone, ovulation, transformation of the follicle to corpus luteum in female and in males it regulates the secretion of testosterone and androsterone.

Luteotrophic hormone (LTH) or prolactin is responsible in active mammary growth and lactation and support corpus luteum maintenance.

Somatotrophic hormone (STH) or growth hormone (GH) stimulates growth (protein synthesis), especially for bones of extremities and skull; raises blood sugar.

ii) Intermediate Lobe :

This lobe is adjacent to anterior lobe, sometimes difficult to identify from the anterior lobe. It secretes intermedin or melanocyte stimulating hormone (MSH). The darkening of the skin in humans is due to this hormone. The regulation of the hormone is controlled by the sunlight. Lack of skin pigmentation is due to its absence.

iii) Posterior Pituitary (or neurohypophysis) :

Anatomically it is intimately associated with the hypothalamus via the hypothalamo-hypophysial fibre tracts, thus forming a component of the hypothalamic neurosecretory system. The hormones are actually secreted from the hypothalamus from where they are transported and stored in the posterior lobe along the fibre-tracts for release. Two important hormones are secreted from the posterior lobe. They are oxytocin and vasopressin (also called antidiuretic hormone 'ADH).

Oxytocin has a stimulating effect on the musculature of the uterus and promotes labour. It also stimulates secretion of milk from the breasts and the stimulus is obtained from the suckling of the baby.

Vasopressin promotes water retention in the kidneys, hence the name antidiuretic hormone (ADH). Secretion or inhibition of the antidiuretic hormone is controlled by osmoreceptors present in the hypothalamus. Excessive intake of water would inhibit the secretion of ADH.

THYROID GLAND :

Thyroid is a bilobed gland. The two lateral lobes are situated one on either side of the trachea just below the larynx being connected with a narrow isthamus - giving the entire gland a more or less H-shaped appearance. Thyroid secretes hormones like thyroxine, triiodo thyronine (T3) and Calcitonin. Iodine is the most essential component of thyroid hormones which is accumulated by the thyroid gland. Thyroglobulin, a mucoprotein is hydrolysed in the thyroid gland by a proteolytic enzyme releasing the hormone in the blood stream. Thyroxine (most common thyroid hormone)is essential for normal growth, skeletal maturation and mental development. Inadequate thyroid secretion retards growth and mental development. The thyrotropic hormone (TSH) secreted by the anterior pituitary regulates the thyroid function. TSH stimulates thyriod gland and elevates the thyroid hormones in the circulation. Hypothyroidism due to less secretion of hormone or reduced iodine intake arrests growth and appearance of other abnormal conditions like protruded tongue and dry, thick lustreless hair and skin leads to cretinism disorder. Myxodema in adult due to atrophied thyroid gland function lowers the basal metabolic rate leading to dry, coarse hair and skin, puffiness of the lower eyelids, thick and coarse voice, dull memory, excessive lethargy, marked intolerance to cold.

Hyperthyroidism is due to excessive thyroid secretion and may or may not be associated with gland enlargement. Goitre is a common case associated with hyperthyridism.

PARATHYROID GLANDS:

There are four parathyroids, two on each side placed ove the thyroids. Parathyroid glands are intimately involved in calcium and phosphorus metabolism of the body. Parathyroid gland secretes parathormone or parathyroid hormone (PTH). The primary function of PTH is to maintain the concentration of ionized calcium (Ca^{++}) in the plasma. It also lowers the serum phosphoru by increasing urinary excretion of phosphate but decreases the calcium excretion. Mobilizes calcium from bone, particularly if the dietary intake of calcium is inadequate and enhances the rate of calcium absorption from the intenstine.

The PTH hyposecretion leads to tetany-a type of muscle spasm. This is due to reduced free calcium in the blood because

much of the calcium in the blood is bound to other substances. Hypersecretion leads to destruction of bone and non-utilization of calcium. This results in the softening of bones and a high blood calcium. Eventually calcium is deposited in the walls of arteries and lungs. In the areas of destruction in the bones fibrous cysts develop and the bone becomes painful and fractures occur frequently. This condition is called osteitis fibrosa cystica.

ADRENAL GLANDS :

The adrenal glands are situated one on either side of the vertebral column, closely applied to the upper poles of the kidneys; hence called as supra-renals. The adrenal glands are surrounded by a capsule of areolar tissue containing fats. The glands are composed of two distinct parts which differ both anatomically and physiologically. The outer part is known as cortex and the inner part as the medulla. The cortex composed of three layers of cells called zona glomerulosa (outer layer), Zona fasciculata (middle layer) and Zona reticularis (inner layer). The medulla is completely surrounded by the cortex. The cortex secretes glucocorticoids and mineralocorticoids hormone. Glucocorticoids (cortisol, corticosterone) which participate in carbohydrate fat and protein metabolism and also concerned with diuretic action, anti-inflammatory and anti-allergic, anti-stress effects. Mineralocorticoids (aldosterone) is involved in Na+ and K+ regulation in the body and carbohydrate metabolism. The medulla secretes epinephrine (adrenaline) and nor-epinephrine (nor-adrenaline) hormones. Epinephrine functions in the increase in cardiac out put rise in systolic blood pressure accelerates conversion of liver glycogen to glucose and raises blood sugar level, converts muscle glycogen to lactic acid, increases oxygen consumption, raises body temperature and basal metabolic rate, stimulates central nervous system. Nor-epinephrine functions in the constriction of small arteries (Vasoconstriction), raises both systole and diastole of the heart and raises blood pressure.

PANCREAS :

The pancreas is a rather diffuse gland which is a mixture of two histologically and functionally separate tissues. The bulk of the gland is exocrine in function. Scattered among the exocrine cells (acini) are patches of tissues called islets of Langerhans and these consists of endocrine cells that directly

discharges secretion in the blood. These cells are small, prismshaped, closely packed together without a lumen; they collectively form an endocrine gland. In mammals Islets of Langshans contain two types of cells, the α - cells and the β - cells. The hormones glucagon and insulin are secreted by α- cells and β-cells respectively. Glucagon increases levels of blood glucose (sugar) by stimulating the conversion of liver glycogen into glucose. Insulin enhances the utilization of glucose by peripheral tissues, helps conversion of glucose into gycogen in the liver and skeletal muscles.

TESTIS :

In mammalian testis, the interstitial Leydig cells lying scattered in between the seminiferous tubules synthesize male hormones, the androgens. The principal male hormone is testosterone. Testosterone promotes the growth and function of the epididymis, vasdeferens, prostate, seminal vesicles and male sex organ. Stimulates secondary sexual characters in males and sexual behaviour.

OVARY :

Two main types of female hormones are secreted by the ovary - the estrogens or follicular hormone produced by the cells of developing graffian follicle and the progesterone derived from the corpus luteum that is formed in the ovary, from the reptured follicle after ovulation. Estrogen promotes the development of female secondary sex characteristics and sexual behaviour. Progesterone maintains pregenancy, development and growth of mammary glands and maintains the foetus by forming placenta and inhibits utrine muscles to contract during pregnancy

In addition to progesterone the corpus luteum of some mammals like mouse, rabbit, dog, cow, guinea pig produce a second hormone termed relaxin which inhibits uterine contractions relaxes cervix and thus facilitates birth.

PLACENTA :

In female, during pregenancy the early placenta (foetal part) secretes a hormone known as chorionic Gonadotropin (CG). This exerts a protective influence on the unborn child and deficiency or absence of the hormone in theearly stages of pregenancy has been associated with abortion. This hormone promotes the production of progesterone from the ovary in the first six weeks of the pregnancy. Progesterone is the gestational hormone - essential for the continuation of pregnancy

THYMUS

Thymus is located in the upper part of the thorax. It is partly an endocrine gland and partly a lymphoid structure. The thymus is quite large in the young animal but as the animal grows, the gland atrophies. By the time adulthood is reached; it is no more than a pair of small lobes lying on either side of trachea. Each lobe has numerous lobules and every lobule consists of a peripheral cortex and a central medulla. Cortex is densely packed with lymphocytes and medulla has less numerous lympholcytes. The thymus secretes thymin (also called thymosin) which is a polypeptide hormone which depresses neuro-muscular transmission. Thymus in the infant mammal plays a major role in setting up the lymphocyte producing machinery of lymph nodes, thus providing the basis for the development of antibodies helping in the immune system.

PINEAL BODY

The pineal body (gland) is a small, pea-sized structure lying deep in the groove between the cerebellum and the cerebral hemispheres in rabbit. Histologically, it consists of parenchyme cells and Neuroglia cells. In lower vertebrates it produces a hormone called melatonin. I tlightens the skin pigments when injected to frog. Its action on the melanophores is thus just the reverse of that of MSH (Melanocyte Stimulating hormone). Melatonin inhibits the gonads both as gamete producers and as endocrine gland in the laboratory rat. In humans, it atrophies at the age of 7 years and its role is uncertain.

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RENAL MECHANISMS AND URINE FORMATION

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Kidney purifies blood by the process of filtration, selective reabsorption and secretion and it maintains the physiologically required concentration of various electrolytes in the different body fluid and plays an important role in the regulation of blood pH. The whole function is carried out by numerous basic units known as Nephrons in each kidney.

Human kidney possesses two types of nephrons - cortical nephrons and juxtamedullary nephrons. Nearly 80 percent of the total nephron bed is due to cortical nephrons and remaining 20 percent comprises juxtameduallary nephrons. The length and position of loop of Henle and the placing of the collecting tubule differs in both the types of Nephrons. The loop of Henle is long and dips deep into the substance of medulla of kidney and the collecting duct of it also travels through the substance of medulla and opens at the medullary pyramid in the case of juxtamedullary nephron. The loop of Henle of cortical nephrons is short and its greater part remains embedded in the cortical substance and only a very small portion of it dips into the medullary tissue.

Nephron begins with a blind-end known as Bowman's capsule. A tuft of capillaries invaginates into the Bowman's capsule to form glomerulus. Bowman's capsule is in continuity with the renal tubule which is functionally divisible into three segments - proximal tubule, loop of Henle and the distal tubule.

The proximal tubule is convoluted, approximately 45 mm long and 55 mμ in diameter. It remains lined by single layer of cuboidal cells. The luminar-surface of these cells bears numerous microvilli which increase the absorptive surface area of these cells. The presence of micro-villi imparts a "brush-border" appearance in these cells. The proximal convoluted tubule opens into the loops of Henle (i.e., the next segment). The loop of Henle consists of three units - the descending limb, a thin segment and an ascending limb. All the three parts of loop of Henle are lined by a single layer of flattened epithelial cell. The ascending limb of the loop opens into the distal convoluted tubule which is comparatively wider and is lined by single layer of cuboidal cells. While traversing through the

cortex, the tubule comes in contact of its own afferent arteriole, the junction being marked by modified type of cells from both components which is designated as macula densa. Distal convoluted tubule empties its contents into the collecting tubule which is lined by flattened epithelial cells. The collecting tubule in turn opens into a collecting duct which finally drains its contents into pelvis of kidney.

Glomerulus is made up of net-work of capillaries which run paralled to each other. The net-work is framed by branching of the afferent arteriole. The visceral layer of Bowman's capsule covers up the outer surface of this capillary net-work. In addition, a layer of flattened endothelial cells and a layer of basement membrane of the capillaries constitute the total thickness of the bed through which glomerular-filterate, has to pass.

An average pressure of 70 mm of Hg is maintained throughout the glomerulus by virtue of a peculiar type of branching of the "renal vascular tree", and the diameter of the lumen of the blood vessels. Branching at any point in the "renal arterial tree" occurs at right angles which prevents the fall of blood pressure to a considerable extent which would otherwise have occurred, had there not been branching. The fall in blood pressure is also prevented on account of the fact that the internal diameter of the afferent arteriole is greater than that of the efferent arteriole. This allows more input and less output of blood which further prevents the fall in blood pressure.

The glomeruler net-work originates as a result of branching of efferent arteriole which enters the Bowman's capsule. These branches reunite within the glomerulus to form a single efferent arteriole which emerges out from the Bowman's capsule just facing the afferent arteriole. Efferent arteriole divides into branches which spread and surround the renal tubule of the same nephron. This forms a peritubular capillary bed. These capillaries reunite to form venule which finally joins the renal vein. A twig from peritubular capillary bed extends along the loop of Henle in a "hair pin" fashion which is known as Vasa recta.

FORMATION OF URINE

Urine formation involves three processes - glomerular filtration, tubular reabsorption and tubular secretion.

Glomerular filtration :

Glomerulus acts as an Ultrafiltration - membrane. It filters out protein - free plasma. The main force that drives the fluid out of glomerulus is the hydrostatic pressure of capillaries (P). This pressure is opposed by two forces, namely the hydrostatic pressure exerted by the fluid in the Bowman's capsule (P_B), and the oncotic pressure of the plasma proteins (Pp),(Colloidal osmotic pressure exerted by the plasma proteins). Thus, the effective filteration pressure (.E.E.P.) is equal to the difference of these opposing forces and may be represented as follows :

$$E.F.P. = P - (p_B + P_p).$$

In all nephrons, such an effective filteration pressure is exerted which drives some of the fluid out of glomerulus into the lumen of Bowman's capsule. The total amount of filterat formed by all the nephrons of both the kidneys per minute is known as glomerular filteration rate (G.F.R.) The Glomerular filterate for normal individual in the course of 24 hours is approximately 180 liters. About 99.5 to 99.7%. of this filterate is reabsorbed when this travels through different segments of the renal tubule. The remaining amount of the filterate - the urine, which constitutes about 1000to 1500 ml. is excreted out per 24 hours.

The average pressure of the glomerular capillaries (p) is about 70 mm of Hg . It may very from 65 to 75 mm of Hg This is the pressure, which acts as the main driving force in the glomerulus. The hydrostatic pressure in the Bowman's capsule (P_B) has been reported to be of the order of 10 to 15 mm of Hg . When blood passes through the glomerulus, nearly 1/5th of its plasma (devoid y protein) is filtered out. Thus, the protein concentration of blood present in the renal glomerular bed is considerably increased and this results in an increase in the colloidal osmotic pressure of the blood proteins. This additional pressure in the renal bed is of the order of 25 to 35 mm of Hg with an average of 32 mm of Hg .

Tubular Reabsorption

The glomerular-filterate passes successively through the proximal convoluted tubule, loop of Henle, distal convoluted tubule, collecting duct system, and finally drained into the

pelvis of kidney, from where it is finally eliminated as urine. While it is traversing through this channel, same of its constituents are reabsorbed to the extent of 99.9 per cent even. Some other substances are not absorbed at all, and a few are added to this filterate by tubular secretion. The substances reabsorbed by renal tubule have been divided into high-threshold substances and low-threshold substances. Renal thereshold value of a substance is that level of the substance in blood, beyond which its complete renal tubular reabsorption does not occur. Those substances which are vital for life and the body can not stand their loss show high renal threshold value, i.e., such substances are not usually lost through urine till they reach fairly high but definite circulatory levels. Below these definite levels whatever amount of such substances appears in the glomerular filterate is reabsorbed renal tubules. The reabsorption of such substances may occur to the extent of 99 to 100 per cent. The examples are glucose, amino acids, phosphate, sodium, potassium, chloride, calcium, ascorbic acid and water. The low-renal threshold substances are usually not required by the body, rather these are harmful. Such substances are reabsorbed by the renal tubules only to a very small extent, or not at all (Ex-urea, uric acid etc.).

In the proximal tubule, essentially 100 per cent glucose and amino acids, atleast 80 percent of water, sodium, potassium, chloride and calcium are reabsorbed. All these substance excent water, are absorbed actively. Water absorption in this segment is obligatory (i.e., it is bound to occur irrespective of the body need). When sodium and other substances are transported from the tubular lumen across the tubular membrane into the peritubular fluid, it causes increase in the solute concentration in the peritubular fluid medium. The proportion of water in the tubular lumen becomes higher in relation to tubular sodium. Thus, an osmotic gradient is established between the tubular fluid and the peritubular fluid, andwater starts diffusing into the peritubular fluid. Substances such as urea whose reabsorption is dependent upon the reabsorption of water are transported passively. The reabsorption of the negatively charged ions, such as chloride and bicarbonate is mainly governed by electrical-gradient. With the transport of positive ions, such as sodium, potassium, calcium, etc., into the peritubular fluid, the peritubular fluid becomes positive in relation to the tubular-filterate which therefore attracts the negatively charged ions from the tubular filterate. After

so many changes in chemical composition, the glomerular filterate enters into the next segment of the renal tubule i.e., the loop of Henle.

The descending limb of loop of Henle is freely permeable for water and solutes, but the ascending limb of the loop is absolutely impermeable for water. It, however, allows transport of the solutes. This peculiarity of the loop of Henle is very important in relation to concentration of urine. The loop of Henle acts on the pattern of counter-current system in concentrating the tubular filtrate. A counter-current system, as applicable to kidney is formed by the ascending and descending limbs of loop of Henle which run parallel, opposite and in close proximity to each other. The exchange of solutes is made possibl by the presence of Vasa Recta. Loop of Henle of juxtamedullany renhron dips deep into the substance of the medulla and its collecting duct again descends back through the medullary pyrami to be drained at the tip of pyramid. An increasing gradient of osmolality is maintained in the medulla, maximum at the tip of the medullany pyramid. This is possible only when sodium and Urea are held in the interstitium of the medullary substance and are not allowed to be drained by the blood. Sodium is absor bed all along the ascending limb of the loop of Henle making the interstitial fluid hypertonic. As a result of it, water from descending limb diffuses into the interstitium and sodium and urea migrate into the descending limb. The fluid in the descending limb becomes increasingly concentrated as it travels downwards. Maximal concentration is attained in this limb of the loop of Henle. It is the hypertonic solution that enters the ascending limb which is waterproof but constantly pumps out solutes in the interstitium. At the end of the loop when fluid enters the distal convoluted tubule, it becomes hypotonic to plasma. Hypotonicity is brought about by active transport of sodium all along the ascending limb which thus maintains the counter-current multiplication of concentration in the descending limb of the loop of Henle.

Hypertonicity of the interstitium is maintained by operation of vasa-recta as counter-current exchanger. Both limbs of vasa recta are freely permeable to solute and water. Sodium and urea come out of the limb carrying blood towards cortex, and diffuse into the limb going towards pyramid. The net result of it is sodium is held in the interstitium whereas water is allowed to go in the ascending limb of vasa-recta.

Counter-current exchange is a passive system which operates secondary to counter-current multiplication.

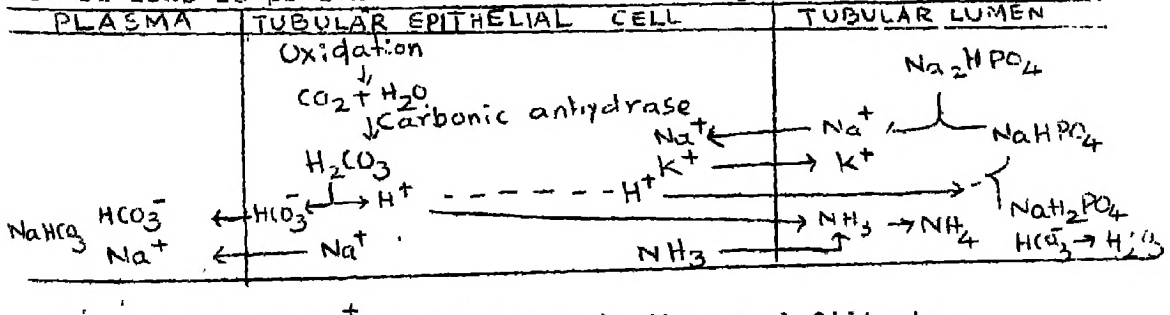
Now the events starts in the distal convoluted tubule. Further reabsorption of water occurs here under the influence of ADH (antidiuretic hormone). ADH increases the permeability of distal tubule and thus leads to 10 to 15 per cent reabsorption of the glomerular fittrate by this segment. Water reabsorption is facultative (i.e. reabsorbed at option depending upon the water requirement of the body) in this segment. It is independent of solute transport but is under the control of ADH.

The glomerular fittrate after traversing through the proximal tubule, loop of Henle and distal tubule enters into the collecting duct system in the stage of isotonicity in relation to plasma. Collecting duct is also under the control of ADH; and besides this the hypertonic interstitum through which it traverses also extracts water and a little sodium from this filtrate. The combined effect of both the factors results in further loss of 4 to 4.5 per cent of the filtrate. Thus, when the glomerular filtrate enters the renal pelvis, 99.5 to 99.7 per cent of its total water is reabserbed in the different segments.

Tabular secretion :

Those products of metabolism which are not at all required by the body, rather they are injurious to health, are secreted out by tubular epithelium in the tubular filtrate. Creatinine, Uric acid, potassium and hydrogen ions are the only normally formed end-products which are secreted by the tubules. However, some of the dyes infused for some purpose, or the other substance i.e. phenol red, penicillin etc. are also excreted out by tubular epithelium.

A more important aspect of tubular secretion is the shift of K^+ and H^+ ions from epithelial cells to renal filtrate/. This shift causes the real loss of H^+ ions from blood, and greatly helps in acid-base balance as well as electrolyte balance of the body. The flow of ions is presented below schematically.



/ in exchange of Na^+ ions present in the renal filtrate.

The tubular epithetial cells secretes hydrogen ions into the glomerular filtrate. Hydrogen ions are formed as a result of dissociation of carbonic acid in the tubular cell. For each H^+ ion secreted into the tubular filtrate, one sodium ion is absorbed by the tubular cell. Bicarbonate ions obtained from carbonic acid dissociation, and the sodium ions absorbed from the renal lumen diffuse into the blood stream in the form of sodium bicarbonate. The hydrogen ions secreted into the tubular filtrate, combine with HCO_3^-, $HPO_4^=$ and NH_4^+ respectively. Such reactions therefore fix up the H^+ ions in the tubular fluid and prevent their reabsorption, rather these facilitate the excretion of the H^+ ions. Exchange of Na^+ ions from filtrate may also occur with the intracellular K^+ ions in addition to H^+ ions.

Thus, the glomerular filtrate is ultimately converted into a well concentrated Urine which measures about 1000 to 1500 ml per 24 hours and shows a PH between 4.8 to 7.5.

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